The SCIENTIFIC MONTHLY

May 1946

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PUBLISHED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
Smithsonian Institution Building, Washington 25, D. C.

THE SCIENTIFIC MONTHLY

MAY 1946

AMERICAN ROAD MAPS AND GUIDES

By WALTER W. RISTOW

MAP DIVISION, NEW YORK PUBLIC LIBRARY

To MANY Americans the end of the war, with the removal of restrictions on gasoline, tires, and automobiles, means freedom to travel. Soon the concrete and asphalt arteries of our land, virtually deserted since 1941, will be pulsating again with the movement of millions of cars. It is interesting to note that this return to the highways comes as the automobile industry is celebrating its golden jubilee.

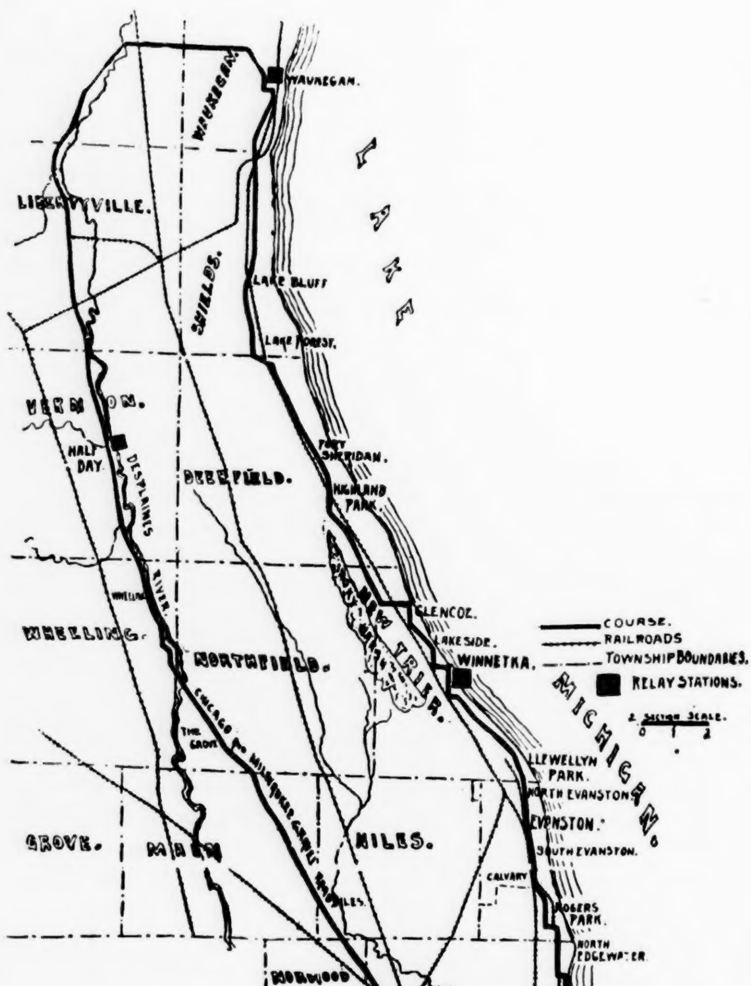
A half-century ago, on Thanksgiving Day 1895, the *Chicago Times-Herald* sponsored a $5,000 auto race, and this historic event, which attracted a number of contestants, decisively demonstrated the superiority of the gasoline car over other types of self-propelled vehicles. Winner of the race was J. Frank Duryea, who drove a car designed by himself and his brother Charles.

The 1895 race was originally planned for November 2, but postponement was necessary to the later date. However, a consolation race was held on November 2, with a Mueller-Benz and the Duryea car the only contestants. The latter ended up in a ditch in a vain attempt to dodge a farm wagon, but the Mueller-Benz completed the 92-mile course from Jackson Park, Chicago, to Waukegan, and back to Lincoln Park.

A map printed in the *Times-Herald*, tracing the course of the November 2 race, is believed to be the first road map prepared for the specific use of American motorists. It was reprinted in the initial number of the *Horseless Age* magazine of November 1895. The route of the Thanksgiving Day race was also outlined on a map in the *Times-Herald* and reprinted in the December 1895 *Horseless Age*. Thus, automobile road maps, too, celebrate their fiftieth anniversary.

The story of the automobile during the past 50 years is an interesting one, and the parallel development and evolution of the American automobile road map is no less fascinating. The excellent and attractive maps distributed free by the millions today are as superior to the two just described as are the modern streamlined passenger cars in comparison with the gas buggy driven by Frank Duryea half a century ago.

As we travel over the miles of excellent highways of the United States today, it seems incredible that less than 50 years ago hard-surfaced roads existed only in and around the larger cities. This was a result of the almost complete dependence upon railroads for long-distance transportation during the last half of the nineteenth century. During these years, highway construction was almost nonexistent. Under such conditions, of course, there was no need of road maps.



THE FIRST AMERICAN AUTOMOBILE ROAD MAP, 1895

FROM THE *Horseless Age*, NOVEMBER 1895. ORIGINALLY PRINTED IN THE *Chicago Times-Herald.*

and virtually all the transportation maps of this period feature railroads and disregard roads entirely.

Shortly before 1890, with the invention and improvement of the new "safety" bicycle, there appeared the first faint indications of a new era in transportation. The growing popularity of the sport of cycling, principally among fashionable and wealthy young men and women in the eastern cities, gave birth to the revolutionary idea of traveling for pleasure.

But to these pioneer cyclists, "traveling for pleasure" was an ideal seldom attained. The roads were in wretched condition, highways unmarked, road maps nonexistent or unintelligible, and the country folk antagonistic or, at best, indifferent to the misfortunes and tribulations of the amateur wheelmen. Following a hazardous Sunday outing, perhaps, one contemporary cyclist, Wilder Grahame (*Good Roads*, **2**(3): 199. 1892) was moved to compose the following lines:

The pathway of life may be narrow and steep,
But the roads through the country are steeper.
The pitfalls and snares that beset us are deep,
But the mud that surrounds us is deeper.

Receiving no help from outside sources, the bicyclists organized in 1880 as the League of American Wheelmen, and thus united they carried on a vigorous campaign for improving and marking the public roads. Travelers in the eastern United States also profited from the pioneer efforts of the L.A.W. in publishing road maps and guides.

Fortunately, by 1890 the United States Geological Survey had published topographic quadrangles for large portions of the northeastern states, and these maps were used by cyclists and also constituted the source of information for most commercial maps and guides. Walker's sectional maps of New England, New Jersey, and New York, widely used by cyclists during the nineties, were almost exact copies of the government maps.

In 1888 Charles G. Huntington brought out *The Cyclist's Road-Book of Connecticut* for the Connecticut division of the L.A.W. This publication, which included 9 individual county maps, bicycle laws, lists of hotels, road directions, and other useful information, may have been the first of the modern American tourist guidebooks. A similar work *The Cyclist's Road Book of New Jersey* was published by Henry A. Benedict in 1890.

Other guidebooks issued by and for the L.A.W. and covering New England, New York, Pennsylvania, and New Jersey soon appeared. As the cyclists increased in numbers, various private publishers also prepared maps and guides, which ranged in price from 25 cents to $2.00. Rand McNally & Company, still one of the leading names in the road map field, published road maps and guides for cyclists as early as 1894.

After 1905 few, if any, bicycle maps and guides were published, for a new wheeled vehicle, the automobile, had won the interest and affection of the amateur mechanics and young sportsmen. The L.A.W. lost members and influence as the new motor-propelled vehicles increased in number and quality. But to the pioneers of that energetic organization motorists owe a lasting debt of gratitude, for it was largely because of the improved highways resulting from the L.A.W. "Good Roads" movement that the early experimental motor cars were able to move easily through the countryside.

Self-propelled vehicles were in existence as early as the beginning of the nineteenth century, but it was not until 1895 that the manufacture of automobiles really became established. For the next 10 years bicycling and motoring shared the interest and attention of wealthy and adventurous young Ameri-

cans. It was natural that the early motorists should avail themselves of the maps and guides prepared originally for cyclists. They, however, soon found these inadequate, for, as one automobile enthusiast of this period noted: "Road maps are not very helpful, as they are usually made for wheelmen. A road may be good for bicycles, as they need only a narrow strip, but an automobile must have wide wagon roads."

Following the example of the cyclists, automobile owners united in 1899 as The Automobile Club of America. Limited at first to motorists within the New York area, the Club soon expanded to include members in other parts of the country. With the American Automobile Association (founded in 1902), with which it later merged, the A.C.A. continued the campaign for better roads and maps started by the League of American Wheelmen.

In 1900 the Automobile Club of America issued its first guidebook, which was described in the *Automobile Magazine* as containing "a vast amount of information that should prove valuable to all users of motor vehicles. It may be said that among other things, it contains . . . road ordinances, legal opinions on automobiles, lists of road books and maps, etc." This early yearbook unfortunately did not include maps, and several more years passed before the A.C.A. entered the map publishing field.

A year later, in 1901, the *Official Automobile Blue Book* made its first appearance. Covering eastern United States, this guidebook included a wealth of useful information, as well as four carefully prepared maps. It set a standard and a pattern which was followed by a number of other guidebook publishers.

Although a few road maps had been issued separately by 1904, most of them before this date were printed in, or as supplements to, guidebooks. From this period, however, individual road maps were prepared by a number of different organizations. In this year Rand McNally published its *New Automobile Road Map of New York City and Vicinity*.

One of the earliest maps issued by the American Automobile Association is a small road map of Staten Island, N. Y., which is dated 1905. The same year the Automobile Club of America started publishing road maps, which were prepared by the George H. Walker Company, of Boston.

Guidebooks continued in popularity despite the increasing importance of maps, and in 1905 the Hartford Rubber Company published a very complete route book called *Automobile Good Roads and Tours,* which sold for $2.00. Covering the northeastern states, this guidebook included a number of page-size maps and detailed touring information.

The first *Official Automobile Blue Book* to carry the endorsement of the A.A.A. appeared in 1906. This popular guide was issued annually until 1926, when it was replaced by the current *AAA Tour Books.* It held top rank among automobile guidebooks during the years it was published.

The Hammond Map Company, one of the early producers of bicycle maps, entered the auto map field in 1906 with a *Road Map of Northern and Central New Jesey.* During the next 25 years the Hammond Company published a long list of motorist maps and guides before abandoning this phase of cartography about 1930.

Automobile and tire manufacturers early recognized the business value of preparing guidebooks for sale or free distribution to their customers. Among the former concerns was the White Motor Company of Cleveland, who in 1907–08 issued a series of *White Route Books* covering various sections of the

Across and Around About Staten Island.

Staten Island (Borough of Richmond, New York City) is best known to motorists as the first stage of the shortest line of road to New Brunswick, Trenton, Philadelphia, and points beyond. Though requiring two ferry transfers as against one across the North River direct to New Jersey, there is a material saving of distance, and the gain of a much less complicated route for, approximately, the first third of the way to Philadelphia. Many tours are planned to go one way and return another.

New York-St. George-Tottenville Line.

Chiefly important is the practically level country road between the opposite extremities of the island — St. George and Tottenville — nearly straight and in excellent condition throughout. This is one main line of the island: From South Ferry, Whitehall St., New York City, take (half hour) ferry across bay to St. George, leaving the ferry slip by left exit. Go straight out to where the way ahead is blocked by irregularity of first cross streets, where bend left and follow Shore Road through Tompkinsville and Stapleton to Clifton, all small places. Entering Clifton turn right on splendid macadam road — Vanderbilt Ave. — direct to New Dorp. Here take left turn (sign) into Amboy Road — a direct, unbroken line across the center of the island, the railroad taking the same general course, with now and then a crossing.

Continue on Amboy Road through Oakwood, Giffords, Eltingville, Annadale, Huguenot, Princess Bay, Pleasant Plains, and Richmond Valley to

16 miles from St. George. Tottenville.
21 miles from Central Park, N. Y.

NOTE. At Tottenville Village leave Amboy Road, keeping Totten St. to Bentley St. to ferry. Amboy Road ends at private dock below ferry, necessitating return and possibly losing boat, if figuring on time of leaving.

The continuation of this run to New Brunswick, N. J., and beyond will be found in full detail in the New York-Philadelphia routes, and somewhat condensed in the tours to and from the Jersey Coast resorts.

Other Connections from New York.

In other ways Staten Island may become a part of tours from New York and vicinity into New Jersey. After the landing at St. George, one may turn right (instead of left as before) and follow upper Shore Road through New Brighton, Port Richmond,

Main road from St. George to Tottenville is the first part of a short line between New York and Philadelphia, the Jersey coast resorts, etc. Diagram shows grades across the island.

HOW TO ARRIVE IN 1905

TOURING INFORMATION AND ROAD MAP FROM A 1905 AUTOMOBILE GUIDEBOOK. (*Automobile Good Roads and Tours*, COMPILED AND PUBLISHED BY HARTFORD RUBBER WORKS CO., HARTFORD, CONN.)

country. Their popularity is noted by a statement in the preface to one edition which boasts that "the circulation of these books is more than twice that of any other publication containing road directions."

The *White Route Book* included one double-page map, photographs, and detailed touring directions. Nothing was left to chance, as the following excerpt will testify:

> Mile 21.5. At the end of the road turn right (school house on the right, church on the left). 23. Turn off to the left with wires (old sign board on the right). 24.7. Turn right with wires, passing on left, after turn, large red barn marked *James White*.

There is no price marked on the *White Tour Books*, and it is possible that they were given to customers. If this is true, it was perhaps the earliest free distribution of published road information to motorists.

By 1909 automobile maps and guides had become quite common, and the *Automobile Club of America Tour Book* of that year lists 20 different maps published by the A.C.A., in addition to a number of guides and maps of other publishers. Many of these covered individual states and were compiled or endorsed by local automobile clubs.

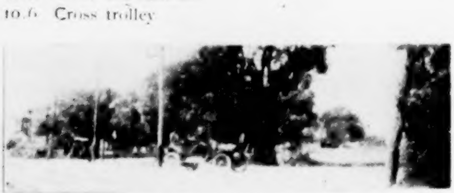
The Goodrich Company followed the

example of the Hartford Rubber Company and from 1912 to 1915 published a series of *Goodrich Route Books.* Including sectional maps of the territory covered, they followed the plan of the *White Route Books* in listing mileages along with detailed directional information. All sections of the United States were covered by the guides, which were distributed to tourists gratis by the Goodrich Company.

Throughout the period 1910 to 1930 there was stiff competition in the preparation of automobile guidebooks, and many novel ideas were tried out. For a time the preferred approach was to outline specific tours, as are found in the *Associated Tours* booklets published by the A.C.A. from 1916 to 1931. Many hotels, resorts, and communities likewise prepared route books aimed to attract tourists to their particular locality.

ROUTE NUMBER 55
CHICAGO TO SOUTH BEND
110 MILES

.0 Leaving the Auditorium Annex go south on Michigan Avenue
.1 Pass on the right the Chicago branch of **THE WHITE COMPANY,** 240 Michigan Avenue
1. Go under railroad viaduct
2.8 At the red light, turn left into 33d Street
3.1 At the red light turn right into South Park Avenue (church on the right of turn)
3.4 Bear slightly to the right on Grand Boulevard, passing large watering trough on the right
4. Go under the railroad
5.4 Enter Washington Park passing Washington statue on the right
5.6 Pass road to left
6. Pass two roads to right which lead from the park and at triple fork beyond take left road
6.2 Pass road to left
6.4 Pass road to left and then pass power house
6.7 Pass road to left and at the road immediately beyond turn left into "The Midway"
7.7 Bear slightly to right under viaduct and one block beyond go straight ahead into Jackson Park
8.3 At the fork with circular grass plot in the angle, take the left road
8.5 At the next fork keep to the right
8.7 Pass road to right
8.8 At the next fork take the right road
9. Leaving the park keep straight ahead
9.5 Cross the railroad at **BRYN MAWR** station
9.8 Cross trolley
10. Cross trolley
10.2 Cross the railroad
10.6 Cross trolley



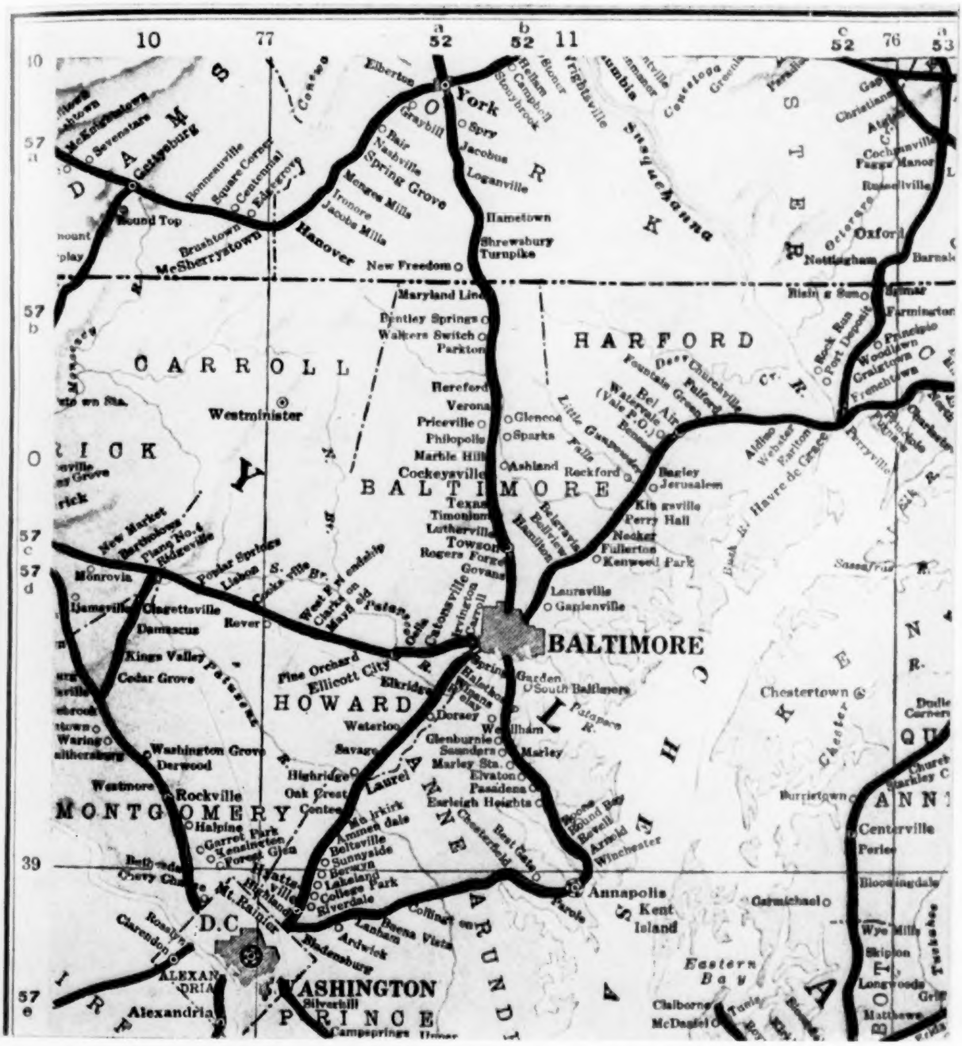
11.1 Make sharp hairpin turn, meeting the car tracks, and immediately turn away from them
12.1 Near railroad bear to the right keeping on macadam road
12.3 Bear to the right keeping on macadam road

12.7 Jog slightly to the right onto asphalt street
13.4 At the South Chicago Hotel turn left into 92d Street, **SOUTH CHICAGO**
13.6 Cross the railroad
13.9 Cross the railroad (lumber yard on the right)
14. Cross drawbridge over the Calumet River
14.3 Cross railroad side track

14.4 At the fork with saloon in the angle, take the right road leaving the trolley
14.9 Cross three railroads; at the next street turn left passing the East Side Station and at the next corner turn sharp right meeting the trolley. At the next street turn 60° left and follow the trolley
15.7 Cross the railroad
15.8 Cross the railroad
15.9 Just beyond the plant of the Columbia Malting Company, cross the state line from Illinois into Indiana
16.9 Cross railroad side track
17. Cross small iron bridge

FOR A FASTER RATE IN 1908

THE MOTORIST WHO USED THIS PRECISE GUIDEBOOK USUALLY REACHED HIS DESTINATION. (FROM *White Route Book*, NUMBER 7. COPYRIGHT 1908 BY THE WHITE COMPANY, CLEVELAND, OHIO.)

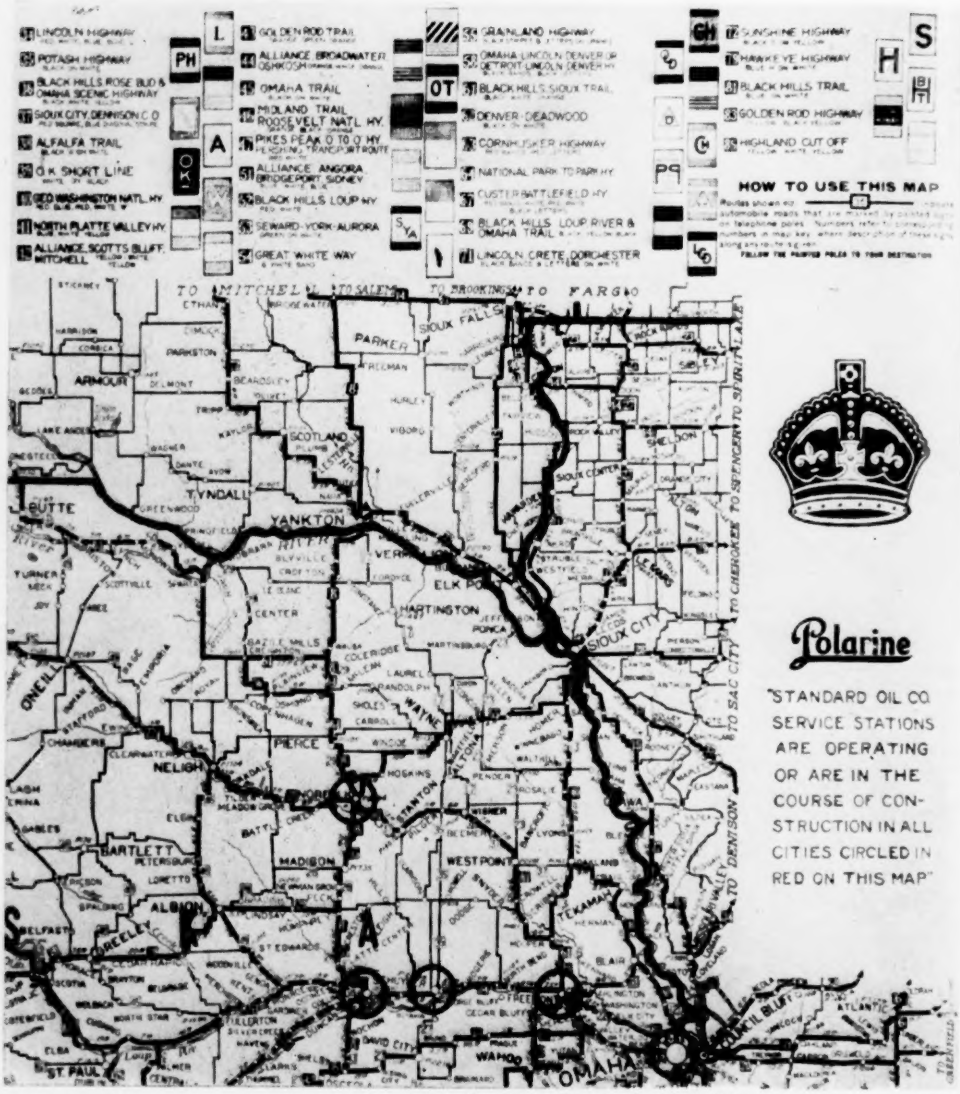


A PART OF AN EARLY COLORED ROAD MAP, 1914

DURING THE 1910'S THE NATIONAL HIGHWAYS ASSOCIATION CONDUCTED A VIGOROUS CAMPAIGN TO DEVELOP ROAD MAPS AND IMPROVE ROADS FOR MOTORISTS. (FROM THE *N.H.A. Tour Book*, 1914.)

In 1911 the National Highways Association was organized and shortly started its campaign to improve and mark the highways of the nation. During the seven or eight years of its greatest activity this organization issued a number of excellent road maps, featuring the several National Highways which crossed the country from north to south and from east to west. The N.H.A. also pioneered in publishing a uniform set of individual road maps for all the states. For the part it took in the improvement of roads and road maps in the United States, the National Highways Association ranks with the League of American Wheelmen.

The year 1913 is significant in the history of road maps. In that year William B. Akin, a Pittsburgh advertising man, sold the Gulf Oil Company on the idea of sending road maps to automobile



Base Map Copyright by Rand McNally & Company, Chicago

THE PERIOD OF THE BLAZED TRAIL, 1921

ALTHOUGH THE FIRST FREE OIL COMPANY ROAD MAP WAS ISSUED IN 1913, THE PRACTICE DID NOT BECOME WELL ESTABLISHED UNTIL THE 1920'S. THIS RAND MCNALLY ROAD MAP, WHICH IS SHOWN IN PART, WAS PRINTED IN TWO COLORS FOR THE STANDARD OIL COMPANY OF NEBRASKA IN 1921.

owners as an advertising scheme. As an initial step, 10,000 road maps of Allegheny County were mailed to motorists in the Pittsburgh area. The following year state maps were prepared, and 300,000 road maps of New York, New Jersey, New England, and Pennsylvania were distributed gratis through Gulf Service Stations. Thus was established a practice which motorists today take entirely for granted and which has placed road map publishing in the ranks of big business.

For several years Gulf monopolized the free map field, and in 1920 this one company gave away more than 16,000,-

000 maps. Within the next few years, however, the other large oil companies recognized the promotional value of free maps and added them to the list of services offered by their stations.

During the second decade of the twentieth century, the American Automobile Association strengthened its position as the leading motor organization in the United States. In 1917 this club issued a series of strip maps covering major highways, but the idea was shortly abandoned in favor of state maps. The A.A.A. state maps soon attained a reputation for their accuracy, and they are today distributed to the number of 2,-500,000 yearly.

As early as 1900 certain of the states had established highway bureaus and issued maps of the road systems. It was not until the 1920's, however, that state departments began free distribution of road maps to motorists. Recognition of the potential profit in attracting tourists within their borders has led virtually every state in the union to adopt this practice. These state highway folders are today frequently attractively illustrated with pictures of the scenic centers or major industries.

The policy of free map distribution had its repercussions among map makers. Prior to 1917 road maps and guides were a motley lot and were prepared by a great number of printers and publishers. Small concerns were able to issue satisfactory maps because touring was still largely limited to short distances, and the necessary road information could thus be easily gathered. Furthermore, the maps of this early period were simple black-and-white affairs, of the type which any small print shop could produce, and they were issued in quantities not beyond the capacities of such shops.

Expansion of the practice of giving maps away forced small publishers to abandon road map printing. Only the larger map concerns were equipped to fill orders for millions of road maps. Such companies also had the financial strength to engage field workers for compiling road information in all parts of the country. The perfection of photo-offset color printing and its adaptation to map making further eliminated smaller concerns because of the high cost of such equipment.

Rand McNally and Company had advanced to a position of leadership in the road map field by 1917. In that year the firm published the first of its automobile guidebooks, the forerunner of the present large *Road Atlas* which is issued annually. Also about 1917 Rand McNally started a campaign for numbering and marking the highways, and this resulted in their series of *Auto Trails Maps,* or *Guides to the Blazed Trails.* These were in the form of large maps covering all or portions of several states, folded to accompany a booklet which listed hotels, garages, and repair shops. By the early 1920's Rand McNally road maps were being printed in several colors, the state unit had been substituted for regional maps, and the maps had taken on a "modern" appearance.

Because of the recognized excellence of the *Blazed Trail Maps,* the Gulf Oil Company in 1918 engaged Rand McNally to prepare maps for free distribution at Gulf Service Stations. For a number of years Rand McNally had no serious competitor in producing maps for oil companies, and at present it remains one of the "big three" among road map publishers. In the prewar period approximately 50,000,000 maps were prepared annually by Rand McNally for several of the large oil companies.

In 1923 the General Drafting Company, of New York City, began making road maps for the Standard Oil Company of New Jersey and the following year took on a similar project for Socony-Vacuum. General Drafting's annual pre-Pearl Harbor output of road

maps (principally for the above two companies) was over 20,000,000.

The third of the "big three," The H. M. Goushá Company, of Chicago, was established in 1926 by several former employees of Rand McNally. It is the only one of the three engaged exclusively in road map production. Between 50–70 million road maps were published annually by Goushá prior to 1942.

The above three companies and a few smaller concerns put out some 150,000,000 road maps before the war for annual distribution through gasoline stations. In addition, the American Automobile Association and the various state highway bureaus disposed of another 10,000,000 free maps. The oil companies pay about 3 cents per copy for the maps, and for the larger companies this item in the annual budget may amount to more than $200,000.

Since Pearl Harbor road maps have been among the minor casualties of war. With our entry into the conflict, road map printers, along with most other map publishers, started working for the Army, and for the past four years their presses have been turning out military maps.

Before the 1946 touring season gets under way, however, free road maps should again be available, perhaps in greater quantities and of better quality than in the prewar period. The 12,000,000 or more servicemen and women, who had intensive training in map reading and who have used the excellent maps of foreign lands, will expect improved road maps. Likewise the millions of us who remained at home have acquired a better appreciation of maps through studying atlases, war maps, and newspaper maps.

Notwithstanding the new emphasis on travel by air, it is fairly certain that for some years to come most of us will do our cross-country touring in earthbound vehicles. And to guide us on our way we will continue to rely upon the familiar oil company road map. Though he may cuss them for an occasional inaccuracy or omission, the American tourist looks upon the road map as a friend in need. For, although road maps have undergone many changes in form during the past 50 years, fundamentally their function is the same. To the cross-country traveler of 1946, as to the gas buggy enthusiast of 1895, they are still indispensable guides and companions in his wanderings over the face of the earth.

CATALYSIS IN INDUSTRY, BIOLOGY, AND MEDICINE

By JEROME ALEXANDER

DURING World War I, C. F. Kettering and Thomas Midgley, Jr., of the Research Department of General Motors, in the course of their collaboration with the U. S. Bureau of Mines to produce an aviation gasoline as free from "knock" as possible, made extensive engine tests with a variety of volatile organic liquids. The comparatively rare hydrocarbon cyclohexane was found to be a superior airplane engine fuel, and the suggestion was made that its manufacture be attempted. Dr. Leo H. Baekeland, then a member of the Naval Consulting Board, regarded the project as impractical and advised against it. He even promised a wooden medal to Kettering and his collaborators if they could make a single pint of cyclohexane.

Nothing daunted, the investigators applied to this problem their knowledge and skill in the preparation and use of catalysts for the hydrogenation of benzene and in a comparatively short time sent Dr. Baekeland a liter bottle of cyclohexane ensconsed in a plush-lined mahogany casket. Baekeland kept this on his desk for many years as a prized possession. And since the product had been made by CATalysis, Dr. Baekeland was furnished with a design for the wooden medal he had promised (Fig. 1).

Today, catalysts and catalysis have achieved extensive publicity. The average newspaper reader, even if he does not know what a catalyst is, does know that 100-octane gasoline, which gives our aviators speed and ceiling, is produced with the aid of catalysts. The more technically informed reader knows that the catalytic production of sulfuric acid, ammonia, nitric acid, and wood alcohol is an old story. In fact, Germany was able to start World War I in 1914 only because she had just then become independent of Chile as a source of nitrates, owing to German perfection of the Haber process, whereby nitrogen and hydrogen can be catalytically combined to produce ammonia. This, in turn, can be catalytically oxidized to nitric acid, the basis of most explosives as well as

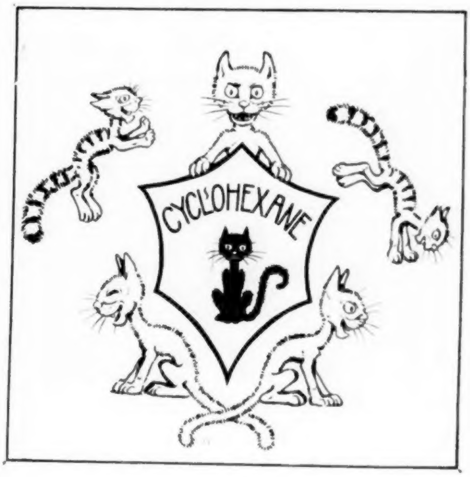


FIG. 1. CATALYSIS
DESIGN OF A WOODEN MEDAL FOR KETTERING. SUGGESTED TO BAEKELAND, WHO DID NOT BELIEVE CYCLOHEXANE COULD BE MANUFACTURED.

a vital ingredient in fertilizers. Those connected with the chemical industry or profession know that an ever-increasing number of useful and valuable organic compounds are now being catalytically produced, some in immense quantities. For example, the 1944 catalytic output of phthalic anhydride, used in making plastics, was over 62,000 tons. In 1936 about 250 tons of nickel were sold in the United States for

catalytic use, about two-thirds having been used for hardening vegetable oils by catalytic hydrogenation to produce a huge tonnage of the well-known edible fats, which, like lard, are nonfluid at room temperature.

To illustrate the magnitude and importance of catalytic processes in the petroleum industry, consider in outline the recently perfected "fluid-catalyst" cracking process, devised by long and expensive cooperative research undertaken by large petroleum refiners, and now operating in about 30 plants (Fig. 2).

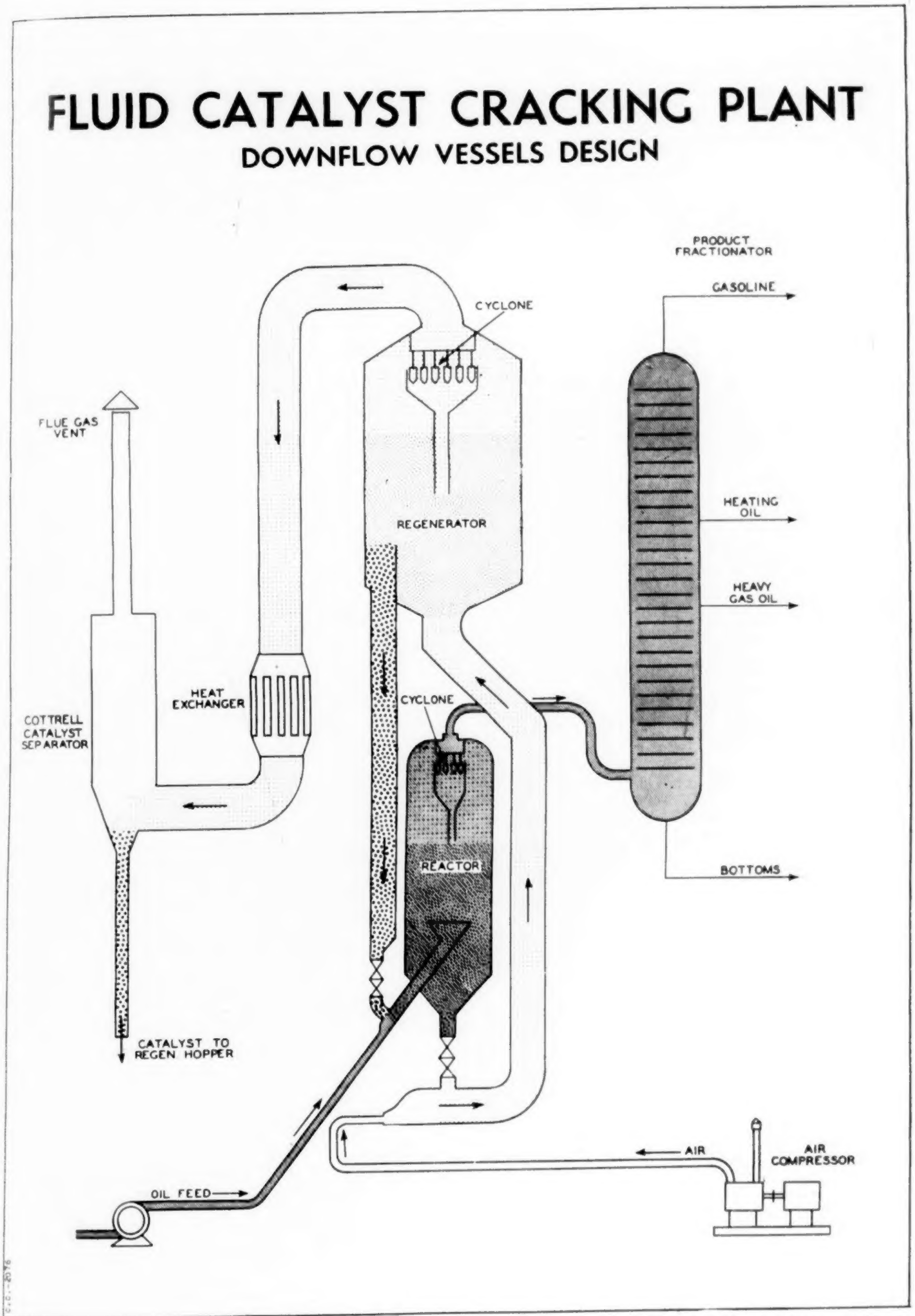
From a standpipe about 200 feet high, a claylike powdered catalyst cascades into a stream of vaporized oil at the rate of about 2 carloads a minute, and the torrid, oily duststorm swirls like a gas into a reactor vessel where, at the huge catalyst surface, there take place the complex chemical transformations termed "cracking." The cracked reaction products are separated from the now blackened, carbon-coated catalyst, which then falls into a stream of incoming air and is carried to a regenerator where the carbon is burned off. The revivified catalyst is returned to the standpipe for reuse at the rate of about 40 tons a minute. About 73,000 tons of catalyst are consumed annually in this process, which has been yielding daily (after certain additions) over 400,000 barrels of 100-octane gasoline. Incidentally, there are also produced certain raw materials for synthetic rubber.

Germany developed the chemistry of coal and coal tar—because she had coal. American chemists realize that besides coal we have in our enormous supplies of natural gas and petroleum important raw materials for a great and novel organic chemical industry, in which catalysts are finding ever-increasing use.

Origin of the Term "Catalysis." A little over a century ago the great Swedish physican and chemist Jöns Jakob Berzelius introduced to science the word "catalysis," and it is well to consider his original definition, uncontaminated by subsequent *obiter dicta* (*Jahresberichte*, 1836, **15**, 237):

> It is then proved that several simple and compound bodies, soluble and insoluble, have the property of exercising on other bodies an action very different from chemical affinity. By means of this action they produce, in these bodies, decompositions of these elements and different recombinations of these same elements to which they themselves remain indifferent.
>
> This new force, which was hitherto unknown, is common to organic and inorganic nature. I do not believe that it is a force quite independent of the electrochemical affinities of matter; I believe, on the contrary, that it is only a new manifestation of them; but since we cannot see their connection and mutual dependence, it will be more convenient to designate the force by a separate name. I will therefore call this force the catalytic force, and will call catalysis the decomposition of bodies by this force, in the same way that one calls by the name analysis the decomposition of bodies by chemical affinity.

Even though recent X-ray research has given to catalytic forces a local habitation as well as a name, Berzelius outlined, in essence, the present view. For example, in 1935 J. Monteath Robertson in Sir William Bragg's laboratory at The Royal Institution, by an elaborate mathematical development of the X-ray data, established the structure and electronic contours of phthalocyanine and nickel phthalocyanine (Figs. 3 and 4). Note how the introduction of a single metal atom (nickel) produces a marked change in the electronic contour at the center. Figure 5 gives a "surveyor's map" of nickel phthalocyanine, the molecule lying flat in the plane of the paper, the electronic maps being foreshortened because the molecules are tilted in the crystal at the angle shown. If we remove the 4 symmetrically placed benzene rings from the periphery of these molecules, we have left an interior ring of 4 pyrrole groups similar to what



Courtesy Standard Oil Co. of N. J.

FIG. 2. CATALYTIC CRACKING OF PETROLEUM

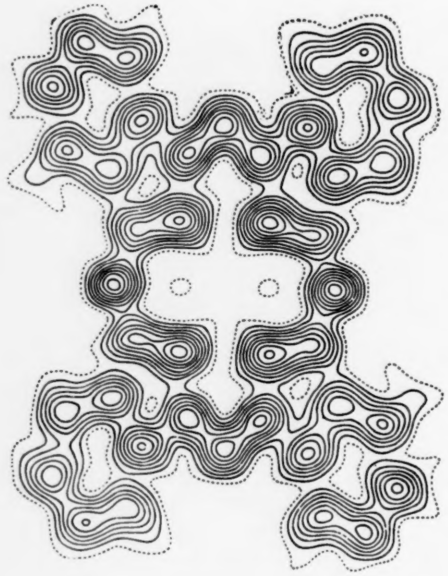


FIG. 3. PHTHALOCYANINE
STRUCTURE AND ELECTRONIC CONTOURS AS COMPUTED FROM X-RAY DATA BY J. M. ROBERTSON.

is found in the porphyrin of hemoglobin (the oxygen-carrier of red blood cells, where the central metal atom is iron) and chlorophyll (a basic catalyst in green plant cells, where the central metal is magnesium). Then in 1938 A. H. Cook found that iron phthalocyanine alone of all the metallic derivatives tried is able to act as a catalyst in the decomposition of hydrogen peroxide; that is, it could function as does the biological catalyst, or enzyme, catalase.

These printed molecular diagrams give merely an inkling of the extreme specificity of the submicroscopic structure responsible for the unique effects of catalysts. And of course they fail to show Brownian motion or the rapid fluctuations in the molecular and atomic electronic fields; that is, the extensive particulate and intraparticulate activity developed by catalysts in action. They do, however, give some idea of the electromagnetic "auras" surounding molecules and indicate the almost infinite variety of electromagnetic "keys" that may be formed to open or to close specific electronic "locks"; that is, to break down (analyze) or to build up (synthesize) specific substances.

In attempting to give a reasonable explanation of the catalytic processes which constitute the basis of so many biological as well as technological processes, we should recall the remark of Daniel Webster relative to political matters, that nothing ever turns up unless someone turns it up. Though catalysts cannot direct lasting chemical changes in defiance of chemical affinities, they very often determine what and when and where specific reactions will occur and their relative velocities.

How Catalysts Function. Catalysts function by virtue of their specific outwardly directed electronic fields of force, which bring about characteristic distortion, or warping, of the fields in susceptible particles (atoms, molecules, ions) that approach close enough and remain long enough to be sufficiently

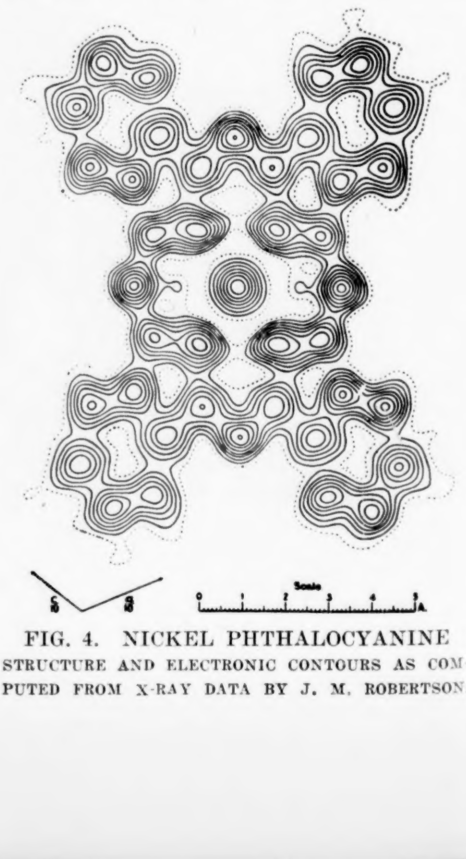
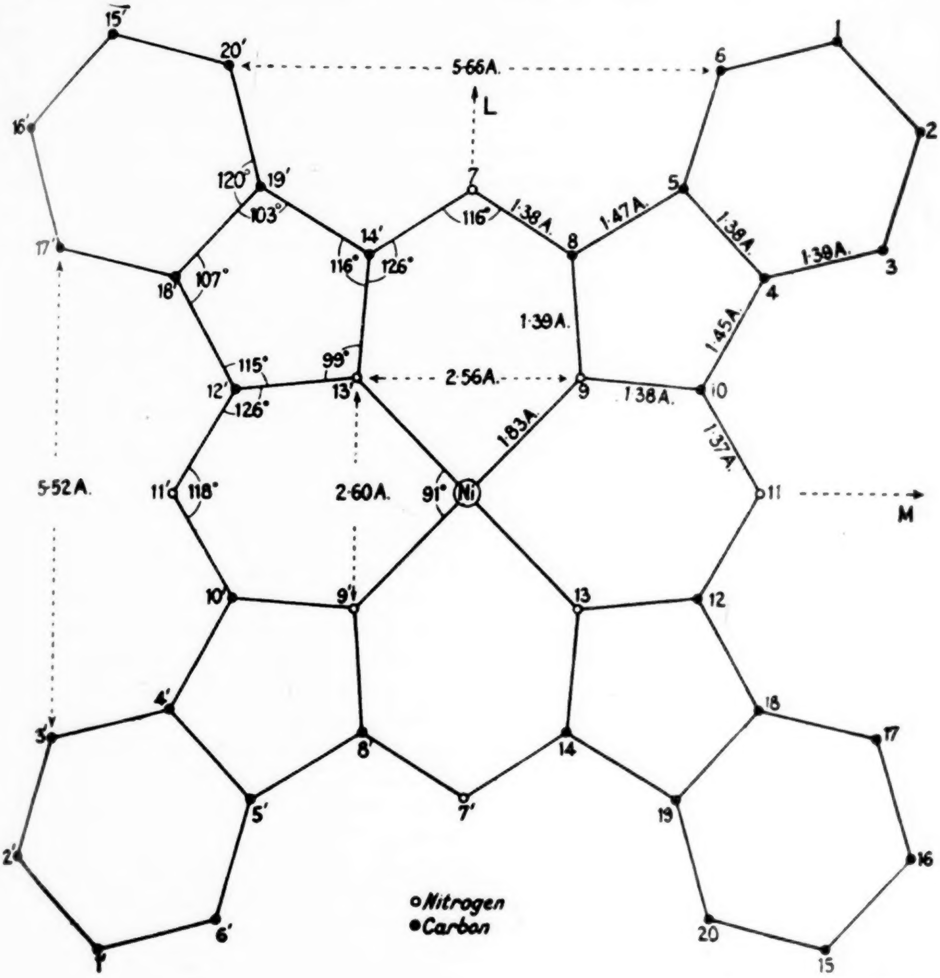


FIG. 4. NICKEL PHTHALOCYANINE
STRUCTURE AND ELECTRONIC CONTOURS AS COMPUTED FROM X-RAY DATA BY J. M. ROBERTSON.

affected to bring about a synthesis or a breakdown. As a result of this distortion, or "activation," the particle may be able to combine with other particles, or it may be split into smaller fractions. Catalysts thus function like a judge, who may wed or divorce qualified couples who come within his jurisdiction and remain there long enough for the operation of due process of law. Another analogy is that the catalyst functions like the "key" of a zipper closure: drawn in one direction, the "key" massages the opposing "hooks" so that they are linked together; drawn in the opposite direction, the "key" releases the bond between the opposing "hooks" and the closure is opened. Within rather close limits the key and the hooks must be mutually adjusted to each other. An adhering bit of paint or solder or a mechanical deformation of key or hooks may prevent proper functioning. Similarly, catalysts may be "poisoned" for certain reactions by physical or chemical change or by adsorbed impurities.



From J. M. Robertson

FIG. 5. DIMENSIONS OF THE NICKEL PHTHALOCYANINE MOLECULE

It is well known by those who use catalysts industrially, that the presence of very small amounts—even traces—of particular substances may make a catalyst function exceedingly well or may completely alter the chemical output of the catalyst. Where such additions are made intentionally to obtain an increased yield of a desired product, they are called "promotors." Sir Gilbert T. Morgan found that when a mixture of carbon monoxide and hydrogen was passed over a catalyst consisting of equimolecular amounts of manganese dioxide and chromic oxide, there was a yield of 80.5 percent of methyl alcohol; but when 15 percent of rubidium was added to the catalyst, the yield of methyl alcohol, under the same operative conditions, dropped to 41.5 percent, while large amounts of different, more complex compounds appeared in the output. By varying the nature and amount of what is added to the catalyst, a great variety of complicated organic compounds may be produced, even under identical operative conditions, from these two gases.

In a way this is a corollary of the well-known fact that the nature of chemical change may vary sharply with the nature of the catalyst. For example, with formic acid the breakdown varies as follows:

Catalyst	Resulting Products
(1) Pd, Pt, Cr, Ni, Cd, ZnO	$H.COOH \rightarrow H_2 + CO_2$
	$H.COOH \rightarrow CO + H_2O$
(2) TiO_2, W_2O_5	$H.COOH \rightarrow H.CHO$ (formaldehyde) + $CO_2 + H_2O$
(3) SiO_2, ZrO, UO_2	

Thoria can catalyze any of these three types of decomposition, depending on the temperature.

Catalysts in Biology. Because a promotor alters the chemical output of a catalyst, it may in a more general sense be termed a "modifier," a term free from any connotations as to the desirability of the result. Since even traces of material may serve to modify, or, as a limiting case, to form a catalyst, the importance of catalyst modification in biological events is apparent; for it is the biocatalysts that determine the nature, proportions, and the rates and places of production of the manifold chemical substances underlying all biological structures and behaviors, both normal and abnormal. Much of the recorded work in biology and medicine describes the consequences of catalyst changes, without considering the comparatively simple principle whereby the extensive and extremely diverse results may be readily understood.

When biochemistry was developing, a favorite gibe of orthodox organic chemists, whose experimental ambit was often the flask, the still, and the autoclave, was: "Whenever a new biological reaction is to be explained, a new enzyme is invented." What was then said in jest is in the main correct, for we have become increasingly aware of the numerous cases in which biocatalysts are brought into being and activity. What had long been known as Warburg's "yellow enzyme" was quite recently reported by O. Warburg and W. Christian (*Biochem. Z.*, 1938, **298**, 150–168; *ibid.*, 1939, **301**, 231–2) to be an artifact resulting from loss of adenylic acid during its preparation. These authors describe five different yellow enzymes of the type of alloxazine dinucleotide, some having similar proteins but different prosthetic groups, others having the same prosthetic group combined with different protein carriers. They estimate that one molecule of dinucleotide can transfer 1,440 molecules of oxygen per minute. D. Keilin and T. Mann (*Proc. Roy. Soc.*, Series B, 1937, **122**, 119–133) have shown that "the same haematin nucleus combined with three different proteins forms three distinct compounds: methaemoglobin, catalase, and peroxidase, which

have many properties in common but show, however, striking differences in . . . their activities."

Just recently S. Granick and H. Gilder (*Science,* **1945, 101,** 540), reporting on the structure, function, and inhibitory action of porphyrins, find that for growth *Hemophilus influenzae* requires hematin, the iron compound of protoporphyrin, which is characterized by its side chains. Though the bacillus cannot synthesize protoporphyrin, it can insert iron into this compound and thus produce the catalyst needed to make oxygen available to the organism and control its metabolism. The bacillus cannot insert iron into porphyrins without vinyl groups, but the latter "could compete with the iron porphyrins for the combination with the specific proteins which go to make up the heme enzymes. Such a porphyrin would thus be a natural inhibitor, and in a sense a regulator governing the degree of anaerobic versus aerobic metabolism."

The term "prosthetic group" requires some explanation. The adjective, derived from Greek roots, means to supply missing parts. Thus prosthetic dentistry deals with the insertion of missing teeth. The prosthetic group (it may be an atom, an ion, a molecule, or a larger particle) puts "teeth" into the catalyst enzyme and helps give it its specific "bite." The same prosthetic group may be bandied about among various "carriers," reminding one of the Norse fairy tale of the solitary tooth that had to serve each of the three weird sisters. On the other hand, the same carrier may be able to accept any of several prosthetic groups, so that from a few basic units many catalysts of diverse effectiveness may be formed.

What are regarded as very "simple" chemical changes in "simple" organisms, may actually be the outcome of complicated reaction series, mediated by many cooperating enzymes, coenzymes, donors, acceptors, and other essential directors of the chemical sequences. For example, the fermentation of glucose by yeast does not yield ethyl alcohol and carbon dioxide directly but proceeds through a series of intermediate reactions each of which is catalyzed by a specific enzyme or enzyme system.

Within the past half-century geneticists have demonstrated that genes are self-reproducing entities, or units, which are the main (some believe the only) carriers of heredity. It is generally agreed that genes act by directing chemical changes as catalysts or by furnishing, through catalysis, "carriers" or prosthetic groups from which other biocatalysts may be formed. Genes are autocatalytic catalysts; that is, they catalyze the formation of precise duplicates of themselves and are therefore to be considered as living units. Although genes are much larger than atoms and the simpler chemical molecules, they are submicroscopic and well within the range of colloidal dimensions, as are also the "macromolecules" of proteins, starch, and cellulose. Some of the self-duplicating bacteriophages and viruses may also be regarded as living units; for while some of these may be very tiny organisms, others behave like large molecules and may even represent the simplest conceivable form of life, termed by Alexander and Bridges a "moleculobiont"; that is, a catalyst molecule capable of autocatalysis.

Living units possess another important power, the ability to undergo chemical or structural changes that alter their catalytic output, without, however, preventing self-duplication in their newly acquired form. If the changed unit is incapable of self-duplication, it is not living. Geneticists have given ample proof that while genes generally breed true, an outstanding characteristic of living units is that they can undergo heritable changes.

Comparatively recently (1927) H. J. Muller found that heritable changes can be produced in the fruit fly Drosophila by exposing its eggs or sperms to selected dosages of X-rays; and similar effects were soon created in many other animals and plants. The gene and chromosomal changes that can be produced are unpredictable, and most of them result in sterility or death. However, as early as 1928 Goodspeed and Olson had developed with X-rays about 120 new varieties of tobacco, all breeding true. While the chemical production of gene changes is undemonstrated, chromosomal mutants have been produced; e.g., by colchicine (an alkaloid from saffron). This leads to diploidy, i.e., cells with doubled chromosome number, and consequent changes in the organism. Many of our well-known plants are polyploids; e.g., certain roses have 56 chromosomes, eight times the normal number in the basic type of rose, but have lost their ability to produce viable seed and are propagated by cuttings. In the Neolithic period in Europe the Einkorn wheats had only 7 chromosomes. Over 7,000 years ago wheats of the Emmer group, with larger grains and 28 chromosomes, were grown in Egypt. The Vulgare group of wheats, to which our modern wheats belong, appeared in the Graeco-Roman period, with 48 chromosomes. No matter how the basic biocatalysts are modified or increased, visible and practical consequences generally follow.

How shall we explain the astonishing but very common fact that from a small and relatively simple fertilized ovum there develop in regular sequence highly specialized and differentiated cells, tissues, and organs? As Ross A. Harrison pointed out, this wonder is thus expressed in the 139th Psalm, (16): "Thine eyes did see my substance, yet being unperfect; and in thy book all my members were written, which in continuance were fashioned, when as yet there was none of them."

Embryologists have shown that certain parts of the developing embryo act as "organizers" by exerting "a morphogenetic stimulus upon another part or parts, bringing about their determination and the following histological and morphological differentiation." The "evocator" is described by Joseph Needham as "the chemical substance, acting as the whole or part of a morphogenetic stimulus emitted by an organizer."

The simple principle of catalyst formation or modification readily accounts for the regularity of the development of the embryo, provided we assume that in the original egg or in its milieu and food there are found the essential specific atoms and molecules needed to form or to modify its biocatalysts. Amounts of specific substances unbelievably small in weight will furnish large molecular numbers. Thus one part of biotin by weight in 400 billion influences the growth of yeast, and certain molds will not grow in the absence of traces of gallium. It is, then, understandable how the cytoplasm of an egg may contain atoms and molecules ample in number and variety to initiate the formation and modification of biocatalysts; and physical or chemical conditions in the developing embryo may lead to the fixation (adsorption) or elution (desorption) of these specific substances at appropriate places and times. Great changes in chemical output, reflected in morphology and physiology, may follow tiny catalyst changes initiated by traces of specific substances.

In the cooperative book *Colloid Chemistry* (Vol. 5, p. 593, 1944) I wrote:

> Catalyst modification, which may in turn lead to the formation of new carriers or new prosthetic groups, offers a simple but potent mechanism whereby nongenic as well as genic changes may be heritably transmitted. This does not mean that any and all nongenic changes are necessarily heritable; but the un-

equivocal demonstration of a single case of nongenic catalyst change would compel us to regard the principle as demonstrated, or, to use a legal analogy, as permissive, though not mandatory, in function.

Recently S. Spielman, C. C. Lindegren, and S. Lindegren (*Proc. Nat. Acad. Sci.*, **31**, 95, 1945) have reported that in the presence of melibiose certain yeasts develop an enzyme capable of splitting this sugar and that the production of this enzyme can be maintained even in the absence of the gene responsible for its initial synthesis, provided that melibiose continues to be present. Apart from the well-established genic inheritance, we have here evidence of cytoplasmic inheritance and therefore demonstration of a mechanism whereby *some* acquired characteristics *might* be transmitted. This mitigated physicochemical aspect of Lamarckism is far removed from the view that led to James Russell Lowell's amusing lines in *The Bigelow Papers* (*First Series*, No. 4, lines 31 *et seq.*):

Some flossifers think thet a fakkilty's granted
The minnit it's proved to be thoroughly wanted . . .
Ez, fer instance, thet rubber-trees fust begun bearin'
Wen p'litikle conshunces came into wearin'—
Thet the fears of a monkey, whose holt chanced to fail,
Drawed the vertibry out to a prehensile tail.

If a heritable catalyst change, genic or nongenic, leads to the formation of substances or structures that give the possessor some advantage in the struggle for food or mates, we must envisage the probability that such a new form will dominate its competitors and, as the fittest, will tend to survive. However, it is equally possible that heritable catalyst changes may lead to very disadvantageous results and thus handicap the descendants.

Excess, deficiency, or imbalance of essential trace substances (hormones, vitamins, minerals, etc.) may lead to such abnormalities as pellagra, giantism (acromegaly), cretinism (myxoedema), etc. The various clinical symptoms (fever, inflammation, swelling, eruptions, etc.) which constitute syndromes of diseases may generally be traced to interference with the normal biocatalysts or with the permeability of tissues or septa controlling the diffusion of raw materials and final products to and from the biocatalysts. Invading organisms such as bacteria or fungi may form endo- and exotoxins which produce effects remote from their places of origin. Though the fungus *Tinea*, responsible for "athlete's foot," commonly grows between the toes, an eczema of the hands is a frequent symptom.

In the early days of medicine diseases were classified by their visible results, and the Greek or Latin professional terms applied to them often added nothing to their popular names. Progress in the understanding, treatment, and cure of many diseases followed investigations into increasingly lower levels of structure: first, by gross dissection; then with the microscope, and, finally, by chemical methods to the invisible but basic chemical level, where the importance of catalysis has become evident, as we may see by considering that group of abnormal conditions called "cancer."

The term "tumor," of clinical origin, originally included swellings of all kinds. It is now generally restricted to neoplasms (new growths) arising from a progressive duplication of cells. If the neoplasm remains localized, without invading surrounding tissues, it is said to be "benign"; if removed by operation, it does not recur. But if the neoplasm invades healthy tissue, it is said to be "malignant"; even if removed by operation, it tends to recur and often sets up secondary growths, or metastases, initiated by cells from the initial growth, which, from the crablike appearance of the invasive tendrils, is called cancer.

About 1914 the cytologist Theodor Boveri published a paper (English translation, 1929, Williams & Wilkins Co., Baltimore, Md., entitled *The Origin of Malignant Tumors*) in which he attributed cancers to a "certain abnormal chromatin-complex, no matter how it arises. Every process which brings about this chromatin condition," he asserted, "would lead to a malignant tumor. . . . Typically, every tumor arises from a single cell," whose definite and wrongly combined chromatin-complex leads to a tendency to rapid cell proliferation, which, in addition to all other abnormal qualities of the tumor, is passed on to all descendants of the primordial cell arising by regular mitotic cell division.

The work of H. J. Muller indicated that treatment of Drosophila eggs and sperms with X-rays can increase by about 1,500 times the expected rate of mutation, perhaps in part due to natural radiations. This gave support to the view that cancer will follow any mutation of a somatic cell which would have as its consequences progressive duplication and invasion of surrounding tissue. Attention was thus focused on the molecular or near-molecular genes and other biocatalysts as the units some of whose alterations, mutations, or modifications could lead to the clinical symptoms of cancer. Furthermore, there is ample evidence that apart from cancer gene and catalyst changes may also produce a great variety of other results in organisms, some normal, some abnormal. So there seems no escape from the view that the genes and other biocatalysts, despite their tiny masses, inexorably dominate the chemical changes in organisms which sometimes lead to results we recognize as disease, and in certain clinical cases to cancer.

A solution of the cancer problem will be at hand when, without causing serious damage to the organism, we can inactivate the cancer-causing biocatalysts or modify them or their products so that the syndrome we call cancer will not result. The proximate "cause" of cancer lies at the biochemical level; but successful efforts to arrest the disease may come from quite different levels; e.g., X-ray radiation, neutron radiation, or surgery if done early enough. Recently (*Science*, 1943, **97**, 541) Charles B. Huggins, of the University of Chicago, reported:

> It is possible by reducing the amount of the activity of circulating androgens to control, more or less but often extensively, far advanced prostatic cancer in large numbers of patients. In this special case, androgen control seriously disturbs the enzyme mosaic of the cancer cells, at least with respect to the important energy producing protein-catalysts, the phosphatases. As a contribution to the problem of cancer treatment, it is well to emphasize that any interference with an important enzyme system of a cell, normal or malignant, will cause that cell to decrease in size and function.

Though cancers are known to follow a diversity of conditions; e.g., mechanical and thermal injury, radiation, virus inoculation, introduction of chemicals like 3,4-benzpyrene and methyl cholanthrene, it is the clincally visible consequences of heritably changed catalysts that lead to the diagnosis "cancer."

INSECT CONTROL FOR THE MARINES

By Lt. (jg) JOHN M. HUTZEL
BUREAU OF MEDICINE AND SURGERY, U. S. NAVY

It was late afternoon, and the Marines were digging in to consolidate their positions before nightfall. To the south Mt. Suribachi poked its squat, ugly peak toward an overcast sky. From its base, and halfway across the isthmus of volcanic ash leading to the northern creviced end of Iwo Jima, heavy artillery sent projectiles hissing overhead to explode seconds later about Motoyama Airfield No. 2. Just off the eastern shore, and north of the convoy of troopships and churning Higgins boats racing supplies to the crowded beachheads, a heavy cruiser surged slowly forward pouring explosives into ravines at point-blank range. Battleships, farther out, maintained an intermittent fire, directed by observation planes above. Upon the captured airstrip, to the left, stood several small Marine monoplanes. Enemy shells dropped in scattered bursts across its runways. The landscape ahead was spotted with puffs of smoke interspersed with the glow of flame throwers and echoing with the rattle of machine guns. Suddenly the artillery fire slackened, and from the east two planes zoomed in low over the beach, a trail of black "smoke" pouring out behind. Thousands of faces turned upward in curiosity. As the planes passed overhead a wave of unprintable language swept the onlookers; not the monosyllabic epithets of adolescents, but the blasphemous, soul-searing well-rounded phrases of Marines in battle. In subsequent flights there was a general scramble for cover, for the coal-black DDT spray speckled the unwary, like measles. Thus did Iwo Jima become the first objective sprayed by carrier-based aircraft for the control of insects.

Airplane spraying was but one development in the Navy's comprehensive program for the control of malaria and other insect-borne diseases. To meet the demand for trained malaria control personnel early in the war, Navy doctors, hospital corpsmen, and commissioned specialists in entomology, bacteriology, parasitology, and related fields were enrolled in special schools. Here they were given thorough review and training in methods of preventing, diagnosing, and treating malaria and other diseases of epidemic portent. Upon completion of instruction the men were organized in malaria control units and epidemiology units. The primary functions of the former were to control insect carriers of disease and make malaria parasite surveys, whereas the latter provided laboratory facilities to track down disease sources and make recommendations for the prevention of disease. Each unit usually consisted of one or two officers and four or five enlisted technicians, and they were deployed among training, garrison, and combat forces, according to need. Marine Divisions were assigned both types of units which operated under one command as a "malaria and epidemic control unit." I shall call it simply a "control unit."

As the war progressed the functions of control units were supplemented by medical research units and rodent control, special sanitation, and construction battalion components. The latter were equipped with draglines, bulldozers, and other heavy machinery for mosquito control and general sanitation projects. Combat forces, such as Marine Divisions, required an extensive program of sanitation to initiate protective measures concurrent with the sudden movement of

large numbers of troops into disease-ridden enemy territory. For this purpose battalion sanitation squads were organized and trained by the attached control unit. Throughout the war the control unit bore the immediate responsibility for the control of mosquitoes and other insects transmitting disease, and its members performed the gamut of duties from poisoning rats to the disposal of enemy dead.

Protecting the health of military personnel in the United States was just as important, though less dramatic, than in forward areas. As the front was approached, however, the problems confronting control units became increasingly difficult, culminating in the protection of troops during combat. Prior to an assault operation of the type undertaken by Marine Divisions the men had to be "educated" to take suppressive drugs, to avoid areas where disease was most likely to be contracted, to eliminate conditions leading to disease transmission, and to use in action the protective chemicals and equipment furnished them. Front line troops were not expected to be overly conscious of mosquito control while subjected to enemy fire, but rear area personnel were required to observe all disease control precautions. Otherwise, an epidemic might have seriously reduced troop reserves and harassed hospital staffs already overburdened with combat casualties. Through lectures, demonstrations, and the use of training films the life histories of insects were outlined, and their part in disease transmission and measures necessary for their control were explained. It was pointed out that atabrine, in most instances, served only to suppress malaria, and when its use was discontinued personnel that had been bitten by infected mosquitoes were likely to develop clinical manifestations. Consequently, the control of insects and protection from their bites was of foremost importance.

In addition to these duties the control unit supervised the impregnation of clothing with repellents and the residual spraying of tents and prefabricated units with DDT. It recommended the type and distribution of insecticides and other sanitation supplies, and loaded special material, including laboratory equipment, for its own use in the field. While the Marine Division was in the staging area, the control unit also carried out all usual functions assigned to it; e.g., sanitation inspections, mosquito and malaria parasite surveys, and control of mosquitoes, flies, lice, roaches, etc.

During invasion and early occupational stages every effort was directed toward immediate reduction of existing insect populations and termination of further propagation. This was most rapidly accomplished by the use of insecticides; the more permanent control programs, such as draining and filling for mosquito control, were gradually developed at a later date. The effectiveness of insecticides, however, depended not only upon toxicity but also upon the method of application and type of dispersing apparatus. To effect immediate control extensive applications had to be made within a few hours. Early control units were equipped only with knapsack, decontamination, and hand sprayers for chemical control procedures. The fact that they accomplished so much with so little was indeed a tribute to their skill and resourcefulness.

The pyrethrum-freon aerosol "bomb" was one of the first outstanding contributions to the technique of insect control used to advantage by Navy personnel during the war. This method of applying an insecticide increased its effectiveness and provided a convenient means of controlling mosquitoes in and around buildings. The aerosol bomb, however, had limitations arising from transitory effectiveness and limited extent of area that could be adequately treated. It was

not until the advent of DDT that modern means of application were fully realized.

The insecticide DDT is a stable chemical that retains its lethal effect against insects long after it has been applied to surfaces on which they alight. Further, it is extremely toxic to adult mosquitoes and flies in minute quantities. These properties made possible its successful adaptation to a variety of means of application of particular value to military forces. The techniques of airplane spraying of chemicals and laying smoke screens were modified to accommodate DDT. Ground operated smoke generators were converted to produce fogs composed of fine droplets of DDT solution that drifted downwind like morning mists across the countryside. The residual toxicity enabled small labor parties working only with knapsack sprayers and paint brushes to set huge booby traps for insects by treating walls of tents and barracks with solutions of DDT. Experience proved no one of these techniques of applying DDT a panacea for all insect control problems, but when used in combination and as supplemental measures the batting average of the control units was increased enormously.

Special emphasis was placed on the development of airplane application of DDT, for this method promised to provide large-scale insect control simultaneously with assault activities. The main advantages of plane spraying stemmed from the speed of application and extent of area that could be treated. Large labor parties could scarcely hope to cover in weeks the variety of insect breeding and resting places effectively sprayed by plane in a few minutes. Moreover, many places susceptible to aerial treatment were inaccessible to ground crews.

Land-based Navy planes were first used to spray DDT during combat at Peleliu in September 1944. It was but one step farther to use carrier-based aircraft in an attempt to close the gap between landing of assault waves and initiation of effective insect control measures.

Prior to the invasion of Iwo Jima a joint session of Army, Navy, and Marine personnel formulated a plan for repeated air spraying of the island. Two torpedo bombers based on one of the accompanying escort carriers were to stand by for spraying when directed by request of malaria control personnel operating with the ground forces. As soon as land-based facilities had become available and the carriers had withdrawn, especially equipped Army planes from Saipan were to continue the spraying program so that no interruption of insect control would occur between the assault and garrison stages. The control unit of one of the Marine Divisions assigned to the operation was charged with the responsibility of over-all sanitation of the island and direction of plane spraying until relieved by the Island Surgeon of the Army garrison forces. This team had already developed two sets of spray apparatus for use in light aircraft of the attached Marine observation squadron and were instructed to take them along in case plans for spraying with other planes failed to materialize.

Spray apparatus and an insecticide concentrate for use in the torpedo bombers were loaded aboard an escort carrier at Pearl Harbor; the concentrate to be diluted with fuel oil carried by the ship. A Navy flight surgeon with previous experience in plane spraying at Peleliu was assigned to brief pilots during the operation and direct installation of the apparatus. Two weeks before D-day a member of the control unit flew to Saipan to coordinate last minute details affecting the transition between Navy and Army spraying.

The assault on Iwo Jima began on D-day, February 19, 1945. For the first few days intense enemy opposition restricted shore activities. Aboard ship,

members of the control unit assisted the overburdened medical staff in caring for the wounded. It was not until D plus 5 that they were disembarked and sent ashore. An immediate survey of the beachhead area indicated that mosquitoes were no problem, but that houseflies were abundant and threatened to become dangerously prevalent. Plane spraying from carriers was impractical prior to D plus 9 because intense artillery fire prohibited low-level flights. An attempt to use a Marine observation plane having direct liaison with the artillery before the torpedo bombers arrived was aborted by enemy shell fire. The plane was knocked out during the installation of the spray apparatus.

On D plus 9 the two torpedo bombers made the first application of DDT. Before they arrived arrangements were made to reduce friendly artillery fire for the spraying interval. During this and subsequent missions treatment was restricted, insofar as possible, to the occupied area, but irregularly drawn battle lines resulted in some spraying of enemy-held territory. Later interrogation of prisoners revealed that the Japanese first thought the cloud of spray was gas. Presumably their observation that most of the spraying was done over American lines allayed this fear.

Surveys conducted the day following the first application showed that the existing adult housefly population had been reduced almost 100 percent. However, breeding still persisted in places inaccessible to the spray, such as in pail latrines and covered refuse, and repeated treatments in conjunction with ground activities were necessary to keep the fly population at a low level. A daily survey indicated the areas most in need of aerial treatment. These were plotted on target maps, and directions were radioed to the responsible air group to spray a given target area. When land-based facilities became available for aircraft and the carriers had withdrawn, Army Douglas Transports from Saipan continued the spraying. They were directed by the control unit until the island was officially declared secured and the garrison commander assumed charge. The combined activities of Navy-Army spraying were similarly employed on Okinawa. Here the tactical situation permitted spraying on D plus 1, and 22 square miles of beachhead had been treated by carrier aircraft before land-based planes took over the spraying.

In spite of its usefulness, aerial application had the limitations of other space-spraying methods; that is, lack of uniform diffusion of the toxicant and short duration of effectiveness. Military personnel continued to depend heavily upon basic ground procedures to carry out the insect control program. The introduction of DDT midway in the war changed the perspective of matériel needs. New methods of application were visualized requiring new types of equipment. However, standardization of equipment for volume production was a time-consuming process. After an experimental model had been successfully demonstrated to Naval authorities, tooling and other manufacturing problems delayed delivery. When finally furnished in quantity to supply depots, the new equipment was held there for months owing to shipping difficulties. Thus at the end of the war control units still relied to a great extent upon hand-powered appliances for the distribution of insecticides. Fortunately, the free interchange of practical ideas and experimental data among authorized civilian agencies, military research activities, and field control units did much to aid the last in designing and building their own insecticide dispersing apparatus to meet emergency needs. The results achieved were little short of phenomenal; a triumph of which all hands, civilian and military, could be justly proud.

THE ARMY'S WAR AGAINST MALARIA

By Major THOMAS A. HART
SANITARY CORPS, ARMY OF THE UNITED STATES

MALARIA has always been a scourge of the world, but not until the recent global war have its devastations been brought forcefully to the attention of the people of this country. The year 1942 was a critical one for the Army with respect to tropical diseases. In the Southwest Pacific area malaria was an acute problem. It is conceivable that mosquitoes alone could have acomplished what the Jap banzai charges failed to achieve. Casualties from malaria in the Pacific four years ago were eight times those from Japanese action. It became urgently necessary to set up an organization of trained personnel to study and combat the situation in the field.

By December 1942 a malaria control organization was established in the Sanitary Corps of the Medical Department. This organization consisted of malariologists, malaria survey units, and malaria control units. The malariologists, one for each theater of operations in which malaria was a problem, were malaria control specialists and liaison officers between higher headquarters and the malaria survey units and malaria control units in the field. Malaria control units consisted of small mobile teams commanded by a Sanitary Corps officer trained in sanitary engineering and malaria control. Malaria survey units were likewise small teams operating from mobile field laboratories. The malaria survey units were supervised by two Sanitary Corps officers; one an entomologist with special training in collecting mosquitoes and identifying them, the other a parasitologist trained in laboratory and field procedures for estimating the status of malaria in a population through blood examination, spleen rates, and the interpretation of epidemiological data. The survey units were charged with the responsibility of searching out and finding malaria-carrying mosquitoes and the type of malaria present in the native population. These findings were made available to the malaria control units and enabled them to set up and carry out efficiently the control measures indicated for an endemic area. By February 1943 this organization was functioning in the field overseas.

The personnel of the field units carried on the battle against the deadly mosquitoes under difficult and trying conditions. They had to adjust themselves to the dank humidity and heat of tropical jungles, swamps, and kunai grass plots. In certain locations wild boars and crocodiles were menacing to them and interfered with their work. Wading hip-deep across streams and walking knee-deep in muck was the common lot of these men. Sometimes they had the eerie experience of losing their way in the jungle or in a tropical mangrove swamp. The matted roots of trees, the trackless jumble of plant life, the half-light filtering through the dense foliage, and the palpable stillness were frightening. The humidity and the insects added to the discomfort and apprehension of the wanderer.

The cooperation of the New Guinea fuzzy-wuzzy and other native laborers in this dangerous work was one of the pleasant experiences the men remember. These people were eager to learn and were willing workers; thousands of them aided in the important work of malaria control. Their usually jolly and carefree manner, their singing on the way to work, and their love of any mechanical equipment, particularly trucks and jeeps,

endeared them to the GI and helped him to banish monotony.

"Man-made" malaria follows the footsteps of an Army in the tropics. Slit trenches, dugouts, abandoned gun emplacements, shell craters, wheel ruts and borrow pits—all water-holding depressions—increase the number of places in which mosquitoes can breed. The Army in the field literally tore up the earth. To combat the tiny mosquito the malaria control units used giant bulldozers and draglines. For grading and filling low, water-holding depressions the bulldozer proved to be a perfect tool, and the draglines were used for ditching to drain off accumulations of water. Whole swamps were eliminated with this engineering equipment. The greatest technical aid developed for the use of antimalaria units was DDT, the powerful chemical insecticide. The discovery of the insect-killing properties of DDT was one of the outstanding wartime contributions to the entire field of preventive medicine. Because it was effective in relatively small quantities, the problem of shipment and transportation of insecticides was simplified. The malaria control units and malaria survey units, aided by this mechanical and chemical equipment, including atabrine, reduced the incidence of malaria to a very small percentage of what it was in 1942. Their heroic and persistent labors helped keep our Army in excellent condition.

These acomplishments resulted from much tedious, hot, sticky work. Research in the jungle, done under the most primitive and difficult circumstances, added to our knowledge of how to combat malaria as well as many other tropical diseases. Radio talks on the "Jungle Network" helped to sell malaria control to the GI. Roadside billboards with luscious pin-up damsels were made, painted, and erected by the antimalaria units to attract attention to the malaria warning carried by the sign. These signs and posters and lectures and radio appeals were all used to educate every man to the dangers of malaria and the best methods he could use to protect himself. Actual control work in the field was a "back-breaking" job. Knapsack containers strapped on one's back were used to spray oil containing DDT on every body of water down to the circumference of a watch crystal. Slow-moving streams choked with vegetation were cleaned out, sometimes by very primitive means. Men, materials, and vehicles had to get to the job through mud and torrential rains. Training new gangs of native labor each week, sometimes at daily intervals, was a drain on patience. To these tasks were added the everyday problem of housing, feeding, and protection of personnel from disease and from Japanese action. Although these malaria units were not combat troops, in the shooting sense, they were waging war nevertheless—a war against disease. They carried malaria control to the front lines and they were there on D-Day with the beachhead landing parties. Their lot was at times unenviable, but usually they were so interested in the job they were doing that no moment was dull.

The fight against malaria has been successful. Through technical skill, educational methods in which all publicity media were used, and intense application to the problems of malaria control and their solution almost unbelievable feats were accomplished against terrific odds. To the malaria control organization, its malariologists, and the personnel of the malaria survey units and malaria control units goes the lion's share of the credit for reducing the malaria rates of the American Army to the lowest level ever recorded for an army in the field in endemic malarious areas.

THE STRANGE CASE OF BLAISE PASCAL

By RUFUS SUTER

THE FRENCH civilization of the seventeenth century was a bright and diversified tapestry. Not only was there talent, but the men and women were remarkable for the complexity of their characters. There was, for example, Antoine Gombault, chevalier de Méré, a gambler, and the arbiter of good taste in Paris. He was outrageously conceited about his mathematical prowess, wrote books on etiquette and the art of sprightly conversation, and strove to be a paragon of elegant manners for all future generations. There was Pierre de Fermat, an honest and respected lawyer of Toulouse and the patron saint of amateur scientists. Despite his legal duties he found time to make contributions to mathematics that have put his name on a par with Newton's. To de Fermat we owe the foundations of the theory of numbers, and to him, as well as to Descartes, we are indebted for analytic geometry. Then there was Antoine Arnauld the younger, a theologian, who was a leader of the religious movement known as Jansenism after its founder, Cornelius Jansen, a bitter critic of the Jesuits at the Louvain. Jansenism, now extinct, was the Roman Catholic version of New England Puritanism, and came the closest to the religion of the evangelical Protestants of any movement within the Catholic Church.

These three men—a gambler, a mathematician, and a theologian—have been mentioned so as to emphasize the versatility of their friend, Blaise Pascal (1623–1662), a precocious youth from Clermont, who came to Paris after his father's death to have his fling at the world. He established himself with the ducal family of Roannais, which traced its pedigree back to Gaulo-Roman days. He fell in love with the Duke's sister Charlotte, the sole heir of her brother's estates, who afterwards married a nobleman of her own rank. After this unfortunate event, the chevalier de Méré hoped to distract Pascal's mind by making a genteel sport of him. No procedure could have been more shrewd, in dealing with a mathematical prodigy, than to suggest the opportunities for mathematical research at the gaming table. The result of the chevalier's good-natured suggestion, however, was only a series of learned letters between Pascal and the respectable de Fermat. But it was a correspondence that has become a classic in the history of mathematics. It contains the foundations of the theory of probability and of combinatorial analysis.

For Pascal the transition from the gay de Méré to the sombre Arnauld was a return to the memory of the authority of his father, who had been deeply impressed by the teachings of the Jansenists. His sister Jacqueline had even become a nun at the Jansenist convent at Port Royal in the outskirts of Paris. The young Pascal, his sense of the uncertainty of human existence quickened by a nearly fatal horse-and-buggy accident, suddenly experienced religious conversion, with all the mystical imagery described by medieval saints. The rest of his short life was spent, one might say, as a "lay" monk, thinking and writing along Jansenist lines. His reverence for Arnauld led him to compose the *Provincial Letters*, a critique of the Jesuits, who had charged the older man with heresy. Although the *Letters* failed in their immediate purpose of ex-

onerating his spiritual mentor, they became the model for the satirical essay in French. Translated into almost every other European language, they were best-sellers for two centuries, and were one of the several causes that led to the suppression of the Jesuit order by Pope Clement XIV in 1773. Pascal's *Pensées,* a set of philosophico-religious meditations, are the only legacy of Jansenism that continue to inspire the religious imagination.

The paradox of Pascal is particularly striking in an age of paradoxical thinkers. As a physicist and mathematician he is the peer of Galileo, Torricelli, Boyle, and Descartes. As a Christian mystic he belongs, in spite of the denominational difference, to the company of our own Jonathan Edwards, the Puritan divine from Connecticut who mixed hairsplitting logic with visions of the spiritual world. Finally, as a skeptic he is almost as disillusioned as David Hume. One would suppose that the mutual incompatibilities among three such contrary points of view would have made it impossible for a single integrated mind to hold them all.

One of the features that makes Pascal an alluring subject for study is the personal incident that was often the occasion for his most impersonal investigations. Thus, when in 1646 his physicist friend, Pierre Petit, came through Rouen, and told Pascal and his father of the experiments in creating a vacuum in glass tubes by an Italian pupil of Galileo, named Evangelista Torricelli, Petit and the two Pascals decided to try the experiment for themselves. At that time the possibility of a vacuum was denied not only by the respectable conservatives, the Aristotelians, who were entrenched in most of the pulpits and professorial chairs of Europe, but also by the right wing of the radical scientific party, the followers of Descartes. It was held that nature "abhorred" a vacuum, and that nature would as soon vanish as to permit the least bit of a vacuum. The experiment Petit and the Pascals repeated after Torricelli was as devastating as that by which Galileo, in the tower of Pisa, refuted the Aristotelian notion that heavy bodies fall faster than light ones. The Torricellian experiment, impressive in its simplicity, consisted in upsetting a glass tube packed with quicksilver into a bowl of the same substance, without letting any air seep into the tube in the meantime. The mercury falls away from the top of the tube, but never reaches a common level with the quicksilver in the bowl into which it is poured. Instead, the encased column stands jutting above the free surface in the basin—an unexpected sight, since there seems to be an unaccountable lack of equilibrium. However this may be, the point that interests us at present is that the space in the sealed top of the tube, after the mercury has dropped, is left empty. Here possibly is a vacuum, though nature has not annihilated herself in its generation. But to return to the odd halt in the drop of the mercury: we see here a second point. Nature apparently has a limited or restrained "horror" of the void, for the column does not fall as low as it could, as if there were a tension holding back the expansion of the vacuum. Indeed, the force by which nature exercises her "horror" is constant and measurable.

Pascal performed this experiment several times before audiences, using tubes of various sizes and shapes, some of them 46 feet long. Descriptions and results were published in his *Expériences Nouvelles Touchant le Vuide.* It is interesting to note that his modest and cautious temper already revealed itself here in his first published essay on physics. Rather than assert confidently that he has proved the possibility of a vacuum,

he is satisfied to state that in his opinion the apparent void is real, and that he will continue to believe so until somebody shows the contrary.

The significant part of Pascal's experiment, however, is not the object for which he performed it. Whether a true vacuum can exist or not is a metaphysical question depending upon the definition of emptiness, and it has little if any relevance to experimental physics. But the second point—the point noted in passing—that the column of mercury remains suspended above the free level of the mercury in the basin, has bearing upon the science of the statics of fluids. Pascal was too modern to imagine that this suspension was literally the effect of a limited "horror" of nature for the void. But then what force is it that prevents the quicksilver from pouring out altogether into the open bowl?

Before the appearance of the *Expériences Nouvelles* Torricelli had made the bold suggestion that this force was the weight of the earth's atmosphere pressing down upon the free surface of the mercury in the basin, and pushing some of it up into the tube. In other words, this experiment exhibited a simple case of the equilibrium of fluids. A column of air (one fluid) counterbalances a column of mercury (another fluid). Pascal knew of this explanation; but Galileo's school, in those days, represented the extreme left wing of the radical scientific party, with hardly a reputable representative in Europe, and the cautious Pascal was wary of allying himself with such revolutionists until all the evidence was in.

So he asked himself this question: Suppose that the earth's atmosphere really does push some of the mercury up into the tube; then, if this bowl, along with the tube, is insulated against atmospheric pressure, should not the mercury in the tube settle to the level of the mercury in the bowl? To test this implication of Torricelli's idea, Pascal and his brother-in-law, Perier (the husband of his sister Gilberte), performed the experiment of the "void within a void"—the whole Torricellian experiment carried out inside of the empty upper end of a larger Torricellian tube. They saw the column actually fall. But Pascal was unconvinced.

He asked himself another question (or, rather, if we accept Descartes's testimony, Descartes posed this question): Suppose that the air weighing down upon the open surface in the basin really does press the quicksilver up into the tube; then, when the apparatus is carried to a higher altitude, should not the mercury be pushed up a shorter distance, since the mass of air above the tube is less? To test this consequence of Torricelli's suggestion, Pascal instructed his brother-in-law to try the experiment on Puy-de-Dôme, a mountain near Clermont, Pascal's birthplace, where Perier lived. The investigation was conducted with all the solemnity of a religious ritual. At 8:00 A.M., September 19, 1648, in the garden of a local monastery, before a small group of honest townspeople, the Torricellian experiment was performed three times with two tubes 4 feet long. The column of quicksilver stood at the height of 26 inches, 3.5 lines. (A "line" equals 1/12 of the French inch of the time, which latter equals 1.065 of today's English inch.) Then, while one set of the apparatus was left in place under the care of a monk chosen for his integrity, the party carried the other set to the top of the Puy-de-Dôme, about 4,806 feet above Clermont. There, in five repetitions the mercury stood at 23 inches, 2 lines, despite rain or shine, open air or shelter. To clinch the argument, there was a retest between the summit and the foot of the mountain and again near the foot. In this last place the mercury stood at 25 inches. Back at the monastery the height was

found to have remained where it was before the party left. Finally, the investigation was repeated in the garden, with parts of the apparatus switched. There was no gainsaying the corroboration of Torricelli's suggestion.

Pascal published a description of this experiment in his *Récit de la Grande Experience de l'Équilibre des Liqueurs,* the last of his essays on physics to appear during his lifetime.

As for the knowledge these studies brought to light: they suggested that the old assumption about nature "abhorring" a vacuum was unnecessary; they added new evidence to the idea that air has weight; they gave us an instrument (the barometer) of use in determining altitudes, and of limited value in forecasting weather; and they hinted that air pressure when applied to partial vacuums can be put to work—can, for instance, lift a column of mercury. Pascal never dreamed how widely this last suggestion would affect our understanding and our mastery of nature. We know today, for example, that an airplane flies because of the availability of air pressure for work in a partial vacuum. We speak of "differential atmospheric pressures" rather than of "partial" or "relative vacuums," but this is a new name for an old face. The propeller, driving out the air in front of the cockpit, creates a relative vacuum into which the weight of the atmosphere pushes the airplane, thus forcing it along its course. Again, the rush of air round the wing driving the air away from the top surface, when the wing is curved in a certain way, causes a relative vacuum to be formed above the wing so that the weight of the atmosphere pushes the plane up into the area of lower resistance, causing the machine to rise.

Pascal's contributions to the statics of fluids were as remarkable on the theoretical as on the experimental side. Two posthumous treatises, *Traité de l'Équilibre des Liqueurs* and *Traité de la Pesanteur de la Masse de l'Air,* present an elaborate system of the statics of fluids. The former treatise belongs in the classical tradition of hydrostatics coming down from Archimedes in that it makes use of a tightly woven deductive method of exposition analogous to the geometry of Euclid. The latter presents the phenomena of atmospheric pressure as a special case under the statics of fluids in general. Pascal's originality as a physicist lies in this masterpiece of systematization rather than in any specific experiment or invention, in all of which he was anticipated by others.

One should also note that Pascal's experiments were perfectly planned arguments to clinch the points he tried to prove. They are as flawless as the ideal examples of scientific method to be found in textbooks of logic today.

As AN experimentalist Pascal was one of the founders of modern physics. As a mathematician he invented, with Gérard Désargues, projective geometry. With Fermat he created the theory of probability and combinatorial analysis, probably the most fertile of his achievements, although neither he nor Fermat could possibly have foreseen what wide application the principles of this science were to have in later centuries. The attempt to bring chance under law has developed into a powerful new weapon indispensable to life insurance statistics, population studies, intelligence tests, subatomic physics, extragallactic astronomy, etc. In the field of applied mathematics, Pascal invented and constructed the first modern adding machine.

We may therefore be astonished that a man who was more successful than most of us in the pursuit of truth should have been dubious about the power to

know. If we consider, however, we will recall that even the ablest scientists have not been outstanding for self-confidence. Newton's comparison of himself to a child playing on the shore of the sea of truth and picking up here and there a bright pebble is not typical, but it represents a frame of mind perhaps more commonly felt than expressed. The skeptical mood, after all, is a phase of the virtue of humility.

Pascal's skepticism has its origin in a sense of the physical smallness of the human being. Some of the early scientific thinkers, like Giordano Bruno, were awakened to a joyous ecstasy by their discovery of the infinitude of the starry sky. But Pascal was depressed. Possibly he could see in the physical puniness of the race some reflection of the moral unworthiness of man. At any rate, he set a richly suggestive example of gloom for the many astronomical writers after him who have painted the familiar picture of the human insect on his tiny ball dropping forever through the chill vastness of eternal night.

It is a curious anomaly that the universe that depressed Pascal—if we may judge by some random passages in the *Pensées*—was Ptolemaic rather than Copernican. He seems satisfied, that is, to speak of the earth and not the sun as the center of the planetary and stellar system. One would have expected him to speak for the heliocentric theory since he showed independence of tradition in his physics. But one should be wary of supposing that this conservatism was dictated by fear of ecclesiastical censure, as was the same reticence on the part of Descartes. Pascal, always cautious about jumping at conclusions, probably felt it premature to declare in favor of the Copernican astronomy. His attitude is clear in the *Provincial Letters* where he chides the Jesuits for obtaining a papal decree against Galileo, the great champion of Copernicus. His point is not that either Galileo or the Pope was incorrect; rather, he wished to indicate that whether the earth moves is not to be settled by papal bulls. In the *Pensées,* moreover, Pascal's aim was to emphasize the physical as well as the moral smallness of human beings, and this is as obvious in the setting of an infinite Ptolemaic universe as in a Copernican background.

Pascal was also made despondent by a complementary picture less familiar to us, of man's stupid hugeness in contrast with the subatomic world. He indulged in a speculation about the atoms being universes, each with its firmament, planets, earth, animals, atoms, etc., *ad infinitum.*

So the complete picture of our place in nature is one of a creature lost between two extremes: that of the immeasurably great and that of the immeasurably small, neither of which we can comprehend. A certain degree of skepticism is therefore unavoidable; but this is a skepticism of extremes. Only an inordinately conceited creature would dream of sounding to the nethermost depths from which he is built up, or of soaring to the outermost edge of the wilderness where he vegetates for a few moments. And for all practical purposes, this limitation on our knowledge is not gruelling.

But if we press further, our pride will collapse altogether. This skepticism of ultimates must dog us in all our science. Take geometry: As the subatomic world disappears into a bottomless well, so the foundations of geometry run down in the direction of ever more nearly ultimate axioms without attaining to one genuinely ultimate. Again, as the world of stars spreads outward without end, so the geometrical theorems to be proved are inexhaustible. The geometer's task is unmanageable: first, because he cannot fully demonstrate a single theorem; second, because he cannot solve all of

the problems the geometrical realm poses. So with the statics of fluids; so with physics in general.

We may flatter our vanity a little if we consider that here again we are concerned with a skepticism of extremes. Let us draw a line at a point in the receding array of premises, and say: Here we shall stop. These we will treat as if they were true axioms. Let us draw another line: This is as far as we shall go in our problem-seeking. Thus by a *tour de force* we have fenced in a neat interval where we can have partial, conditioned, relative science. Pascal, like Hume, attributed much of what we call knowledge to habit.

The genius of Pascal's skepticism is that it is enlightened common sense. He is merely a cautious experimentalist and mathematician, his conclusions tempered by Christian fear of intellectual pride, who knew the obstacles and blandishments in the path of complete proof. For science, both absolutely certain knowledge and absolutely certain ignorance are unattainable. One would go far to find a restrained, balanced estimate of the human capacity to know equal to Pascal's.

The clue to Pascal's skepticism is, of course, his religion. An important part of the Jansenist teaching, as well as of the Puritan, was the idea that man is inherently evil. To the average Jansenist or Puritan Father, moral weakness was bad enough to exhaust the gruesome possibilities of this state of ruination. But for Pascal the old dogma of total depravity had a broader meaning. Man is feeble in wit as well as will. It is as impossible for a scientist to know anything unqualifiedly true as for men in general to will anything good. This condemnation applies only to what the theologians called the "natural" man, that is, man exiled from the source of truth and good. But since "regenerate" men—that is, men who through conversion have been reunited with the source of truth and good—have their interest turned in a different direction from the natural sciences, the condemnation amounts to a general suspicion of the human power to know.

In the end, Pascal's religion swallowed him up. After his conversion he abandoned his scientific inquiries, save for one or two half-frightened instances, and excelled Jonathan Edwards, or any of the Puritans, in his brooding over the sense of sin, and in prayer and Bible-reading. Some of his critics attribute this change to a mental and physical breakdown. For many years, indeed, a day never passed that he did not suffer acute physical pain. After his death, which came during a convulsion, his whole digestive tract was found to have collapsed and his brain to contain a lesion. But one should not discredit the last phases of Pascal's thought solely because he was diseased. His religious preoccupation may have been induced by mental and physical suffering, but this of itself does not constitute sufficient evidence that any of his insights were worthless. We should weigh the possibility that humanity really is corrupt, that the cognitive faculties are slightly out of focus, and that part of Pascal's genius was that he recognized this. As a matter of fact, we should, perhaps, even be willing to consider the idea occasionally that insights of a different order from those achieved in the laboratory and in mathematical reasoning may help to resolve our quandaries.

It is not unintelligibly erratic today for a biochemist, for instance, to turn Marxist, and to substitute the method of thinking associated with the materialistic dialectic for the customary processes of experimental science. In seventeenth century France, a Catholic physicist and mathematician who turned to the Bible was no more of an anomaly.

INTEGRATION IN SCIENCE TEACHING

FREDERICK S. HAMMETT

THE LANKENAU HOSPITAL RESEARCH INSTITUTE, PHILADELPHIA, PA., AND NORTH TRURO, MASS.

WHO WILL deny that "... everything in our experience is only a part of something else that in turn is only a part of still something else"? This concept of interdependency between the things, states, and events of environment is as old as ancient Indian cosmology and has been variously stated down through the years by many thinkers, not the least of whom are Pareto, Smuts, and Cannon. And who would deny that this business of living may be facilitated by increasing knowledge of how these somethings are part of each other?

Clearly, the function of science teaching, as of all teaching, is to guide all students to knowledge of the known relations and to prepare some students to add to that knowledge. The states of mind with which such students approach the unsolved problems and the ways in which they go about getting new knowledge are some index to the efficacy of the preparation.

It would seem that those who deal with the products of science teaching as research assistants are in a good position to judge of its efficacy and are perhaps better qualified than the teachers themselves to make suggestions for its strengthening. The proof of the pudding is in the eating, not in what the cook says about it.

Nine years of teaching and thirty-odd years of experience with the products of others' teaching from colleges and universities in this country, Asia, and Europe have naturally given me ideas. But let us first consider the evidence.

Proficiency in technique is compounded of two elements: awareness of basic principles that are universally applicable and facility in manipulation. Awareness comes from instruction; facility from experience. It cannot be demanded that science graduates be technically facile. But it can be expected that they be sensible of what constitutes proper conduct of experiment. Graduates in chemistry, biology, and kindred subjects have had to be taught the following:

(1) Orderliness in the keeping of records and segregation of data and impedimenta; (2) neatness and cleanliness of worktable and apparatus; (3) avoidance of contamination of experiment with material not pertinent thereto; (4) respect for apparatus, and its use and care; (5) respect for organisms, their feeding and gentle handling, and the desirability of performing experiments under conditions approximating the natural habitat as nearly as possible; (6) a sense of variables, or how and why genetic, chemical, physical, and structural factors of possible interference in experiment and not pertinent thereto should be stabilized; (7) a sense of controls, or how and why test material should match control in all respects save the experimental variable being tested; (8) accuracy in observation and measurement; (9) simple arithmetical procedures; (10) avoidance of conscious and unconscious bias; (11) and that just as one swallow does not make a summer, so not one but many experiments must be run before decision is attempted, and that when organisms are used, many are to be tried.

One could expect that students and teachers alike would accept the following: (1) That identification of control and test glassware is facilitated by marking one set with blue pencil, the

other with red; (2) that worktables cluttered with extraneous supplies are conducive to mistakes; (3) that tobacco-tarred fingers, cigarette ash and smoke are possible contaminants of solutions; (4) that the inside of dishes being used or to be used in experiment is no place for fingers, no matter how seemingly clean these may be; (5) that soap in any form is no proper cleaning agent; (6) that phosphate, HNO_3, chromate-sulfuric acid mixture, and other chemical cleaning agents must be thoroughly removed by repeated (70) rinsings in hot or cold tap water, followed by others (30) with distilled water; (7) that watch glasses, not filter paper, should be used on the balance pan for weighing; (8) that filter paper rather than sulfite-loaded paper towels should be used as the moisture carrier in moist chambers; (9) that to mix solutions by blowing through a pipette is pretty sure to result in fouling of cultures to which such solutions are added; (10) that test and control cultures should be matched for pH, illumination, and temperature; (11) and that many specimens in a single culture dish and infrequent changing of culture solutions are not conducive to reliable results. But it sometimes seems that if there is a wrong way to do things, this will be the way chosen. The amount of time, effort, explanation, and patience required to eradicate bad habits and replace them by good ones can readily be imagined.

What all this shows is that graduates and teachers alike are quite untutored in the fine art of meticulous experimentation. And they are untutored because their foundation does not include apperception and/or working knowledge of one or more of the four interdependent basic attributes of all phenomena, viz., direction, substance, state of substance, and form.

This is also evident in the states of mind with which science graduates approach the problems of research. Some have the idea that science is nothing more than the accumulation of data like that contained in a handbook of chemistry or Pratt's Manual. These envision a problem as occasion for collecting and recording only. Such may become as "sounding brass and a tinkling cymbal." Useful but not very inspiring.

Some have the idea there is no science other than that comprised in the subject of their preference. These envision a problem as occasion for learning more and more about less and less. Digging a pit, they fall into it. For them all horizons are lost.

And some, awed by professorial pontifications, see nothing more in science than the dogmas promulgated by their instructors. All else is heresy. To such, a problem is occasion for proving the dogma right, all other ideas wrong. They know not that facts make the theories, not theories the facts. And authoritarianism is their god.

The degree of possession varies from individual to individual. It ranges from fanatical adherence to innocuous desuetude. But all are possessed by one trait or another. This indicates that science teaching effects a trend to canalization in the thinking of science graduates about research. When development follows this path there is first a groove, then a rut, and finally a molelike tunnel within which the worker bores his isolated way, uninterested in other tunnelers, uninteresting thereto. A digger, not an architect.

Correlative evidence that science teaching directs its disciples toward narrowing rather than expanding points of view is found in the fact that these traits are least noticeable in those who have gone no further than the A.B. or B.S. degree; are only confusedly held by those who have the M.S.; but are in full flower in the Ph.D.s.

These observations suggest that sci-

ence students are indoctrinated with what Charles Fort calls exclusionism, and that those who prepare students for research are separationists in practice, if not in theory. This trend to isolationism obfuscates the functions of science teaching. It results in one-sided interpretations. It leads to impasses, the multiplication of words without meaning, and the development of the defense mechanism of the stuffed shirt.

The foregoing is evidence enough that science teaching should pay more attention to the interdependencies. The almost hermetically sealed walls that separate subject from subject should be broken through. And there should be a shift from subject compartmentalization to intersubject integration.

I am quite aware of the truth that the mass of data accumulated on any science subject is so great that exposing students to it takes practically all the time allowed for its teaching. But I wonder if *all* the data of any subject is ever presented, and if it is, if it can be assimilated or even retained by any student. And I wonder if the time has not come to give up trying to crowd mind and memory with data that can be found in texts, and instead to start from principle, use data to illustrate, and direct students to use texts for data and mind and memory for understanding.

If this were done intersubject integration could easily be accomplished since the data of every science subject are united in the common possession of the basic interdependent attributes of direction, substance, state of substance, and form (Hammett, 1941).

A chemical reaction, an astronomical traverse, a mathematical formula, an organismic evolution, a philosophical concept, each and every one has direction, substance, state of substance, and form. The principle is universally applicable.

It is proper to use biology for exposition since more members of the American Association for the Advancement of Science are interested in biological subjects than in any other branch of learning. In biology, then, direction is comprised in the subject of genetics; substance in that of chemistry; state of substance in physics; and form in that of anatomy.

The pattern of organisms is ineluctably shaped by direction. That pattern is expressed regardless of impinging environmental influences. Pattern is expressed through substance. Direction works through substance to produce pattern. Substance cannot express pattern without direction. And direction cannot be expressed without substance. Direction and substance are therefore interdependent aspects of biological processes. And holistic exposition of biological mechanisms can neither be based on genetic direction alone nor on chemical composition and reactions. Both must be invoked.

Substance exhibits certain states such as color, viscosity, surface tension, electrical differentials, and so on. State of substance is an ubiquitous and basic aspect of organisms. The states which substance exhibits are the product, not the producers, of substance. But state of substance influences the extent and rate of chemical change and exchange. Therefore, substance and state of substance are interdependent aspects of biological processes and their end products. Direct interdependency between state of substance and direction is not always obvious. But since direction and substance, and substance and state of substance are interdependent, state of substance and direction are interdependent through mediation of substance. No well-rounded exposition of biological phenomena is possible if only the data of genetic direction, chemical composition and reaction, or physical state are used. The contribution of all must be used for understanding.

Form is basic and definitive as aspect of organism. The forms of organisms are set by direction, molded by substance, and limited by state of substance. Conversely, changes in form may affect state of substance, rate of chemical reaction, and extent of genetic expression. Form is thus interdependent with direction, substance, and state of substance. And holistic exposition of biological processes cannot be had from form alone; but only from this, plus the data of genetic direction, plus the data of chemical composition and reaction, plus the data of physical state.

Every biologist knows that organisms are integrated. The foregoing is a brief demonstration of how integration is effected through the interdependence of the four basic attributes of direction, substance, state of substance, and form. *It is apparent that there are no boundaries in science; there are only interdependencies.* This precept is of course generally applicable. Its extension to all teaching could help avert the stupidities of war, racial bigotry, and class strife.

These things being so, it is evident that science teaching can and should direct its attention somewhat more to intersubject integration, and somewhat less to subject compartmentalization. By so doing its utility and effectiveness would be enhanced. The logical basis for such a step is unassailable; its advantages are not obscure.

It is a job for the young teachers. Their minds are likely to be more labile and less irrevocably coagulated than those of the older. It will be an adventure from which much of use may come.

And for biology let there be established in every department a course in biological chemistry equivalent in coverage to that now given to medical students, who, by the way, are really students of applied biology. Let it be required for all students of biological subjects, be these botanical or zoological.

This is advocated because experience shows biology graduates without exception to be incapable of even the most primitive analysis of biological processes in terms of chemical activity. Their ideas thereon are grotesque. They either close their minds to the fact that the organisms they work with are composed of chemical compounds, and the processes they study are expressions of reactions between these compounds; or they take ignorant refuge in the meaningless use of such wastebasket words as metabolism, respiration, enzyme, and the like for their explanations.

It is through chemical composition and reaction that direction, state of substance, and form are expressed. So how can it be expected that any biology student is properly prepared to study organisms holistically if he is unacquainted with the principles and properties of the substances of which they are composed? And who will deny that organisms should be studied holistically?

Clearly something more than lip service could be given to the principle that there are no boundaries in science, only interdependencies. And clearly science teaching should be reoriented on a basis of intersubject integration, if it is to live up to its responsibility of leading all students to cultural and pragmatic knowledge of the integrity of environment, and some to adding to that knowledge.

In 1897 Justice Oliver Wendell Holmes said in an address at Harvard:

> Your education begins when you . . . have begun yourselves to work upon the raw material for results which you do not see, cannot predict, and which may be long in coming. . . . No man has earned the right to intellectual ambition until he has learned to lay his course by a star which he has seen—to dig by the divining rod for springs which he may never reach. Thus only can you gain the secret isolated joy of the thinker, who knows that, a hundred years after he is dead, men who never heard of him will be moving to the measure of his thought.

AN ADVENTURE IN SYNTHESIS

By OLIVER JUSTIN LEE
DEARBORN OBSERVATORY, NORTHWESTERN UNIVERSITY

EVEN to the man who labors to increase knowledge because he finds deep satisfaction in this activity and who professes knowledge because he loves to lead students into an appreciation of it, the world of knowledge seems indescribably wide and complex. The present is a far cry from the days of simplicity when a polymath could encompass in his own mind most of the knowledge of his day. This ancient scholar could at least maintain a speaking acquaintanceship with some of the unities, which must have pierced their red ways through most of his intellectual experiences.

Came the age of science, the departmentalization of knowledge, and the resultant "confusion of tongues," as men's researches became deeper and deeper and more and more narrowly confined to their own special areas. What chance, O Unities?

Add to this the tremendous increase in the complexness of life in a modern civilization, with its hysterical sense of speed, its far-flung relationships that span the globe and even reach to the most distant observable galaxy. What hope for you, O Unities?

To the experienced scholar and teacher, no less than to the eager-eyed freshman who comes seeking confirmation into the intellectual world, a glance at the lists of courses of study offered by any large university yields humility and a sense of bewilderment. The latter is hardly mitigated by four or more years of intelligent study.

The student is conscientiously led into the intricacies of knowledge and instructed to criticize, to question everything—the law of gravitation and even his own existence. Overanalysis and lack of perspective often lead to paralysis of the mind and the will. This in turn leads to dissociation of the intellectual world from the outer so-called world of reality into which the young person is thrown willy-nilly to sink or survive in the maelstrom of superficial change under the unhappy aegis of chance.

To be sure, statistics do show that the so-called educated person does make more of a success of his life by traditional standards than he who has not gone through the educational mill. He has gained a certain amount of skill or agility in adjusting himself profitably to his environment. What he studied seems to have mattered less, unless he enters one of the regular professions, in which pressure, applied internally, compels him to learn, to know, and to understand facts. For the rest, the great majority of college people, no basic principle or precipitate of understanding seems to have survived the years.

In the physical world certain laws of motion have been formulated which express the relationships of mass, energy, or force and motion. Newton's Three Laws of Motion and the Law of Universal Gravitation form the basis of Mechanics, and, given the underlying facts, they can be used to express satisfactorily most of the motions in the universe, no matter how complicated and interrelated these may be.

May there not be some similar statements made which will simplify the apparent chaos in our experience with Nature and Society?

Reflection indicates that this can be done. First, however, it is necessary to free our minds from nearsighted attention to *bewildering change* and to drive

our intellects deeper into the matter to search out the *laws of change*.

Change itself defies description except as single cases or categories of cases. The laws of change are few in number and relatively simple. In fact, it is not hard to show that, if we consider the action, reaction, and interaction of basic forces and tendencies in Nature and Society, about the reality of which all earnest minds must agree without debate, three short statements express the results.

1. A surging, pendulum-like swing to and fro, which may result in a static or a dynamic equilibrium.
2. A trend, operating over a long or short period of time, which may or may not reverse itself.
3. Various combinations of these two.

Four years ago sixteen members of the Northwestern faculty (seven, including myself, were heads of departments) got together to talk about such ideas as fundamental forces and processes; balances, imbalances, trends, and equilibria, and the possibility of associating them for our students in our various fields as, let us say, an adventure in synthesis.

Before long, twenty of us, nearly all seasoned teachers, research men, and authors, found ourselves each writing a chapter for a book on the significance of trends and equilibria in the study of Nature and Society. The directions were simple:

1. Do not try to write a survey of your fields.
2. Analyze your material so as to discern basic forces, tendencies, and processes which struggle more or less successfully for supremacy.
3. Select two or three pairs or groups of these contending elements and write about them as simply as you can, after divesting them of most of the adhesions which tend to strangle a subject when we teach it professionally.

Practically every fundamental field of knowledge and expression is included. They range from mathematics to law, from physics to literature, from astronomy, religion, or economics to music and philosophy. It has been interesting to note that in not a few instances the author has discovered a welcome new light upon the analysis of the material in his own field in the process of thinking about and writing his chapter.

The course was approved by the faculty of the College of Liberal Arts in the spring of 1943, and the book has been copyrighted by Northwestern University.

The shadows of the war and our own war efforts closed down upon the enterprise, to be lifted only last summer.

Last spring we selected a small group of superior juniors and seniors for a class and prepared to give the course this past fall and winter.

In the first quarter eleven of us each gave two lectures and conducted one period of discussion in which the class of sixteen usually grilled the lecturer royally. In the second quarter the other ten (geography was added) concluded the course for the year in ten weeks. Next year the course will be open to general but limited registration.

The matters of the student's participation in the work of the course and of evaluating his understanding of its significance have been worked out satisfactorily. It should be stressed that this course is given only to upperclassmen and women who have learned to think independently and constructively and to graduate students, who are assumed to be thinkers.

My colleagues and I are giving it with the earnest hope that the student will find in it something approximating a compass and rudder for his voyage through the apparent chaos of life. We trust it will aid him to develop an intelligent, constructive, and satisfying personal philosophy for living, characterized by confidence in the essential order in Nature and Society, poise of mind, and peace for the spirit.

CRITERIA OF PATENTABILITY

By J. HAROLD BYERS

No one holds a patent on the instinct of contrivance. Aptitude, however, is developed in men in different degree. The difference is due in part to incentive and opportunity, and in part to innate ability. The impulse to invent perhaps may be stimulated by hope of reward, but frequently the creative faculties flourish on lighter fare—on nothing, apparently, more substantial than some inner urge. With some men, invention is a consuming passion.

Scientists by nature and environment are especially inclined and equipped to make valuable inventions. Most scientists have at some time considered taking out one or more patents. Some, for one reason or another, dismiss the intention; others determine to proceed. Those who are members of the research staffs of large organizations that take out patents as a matter of course turn their inventions over to patent counsel.

The benefits of taking out patents include: publication of the inventions; credit for original work; control over important developments; financial remuneration; and protection against the possibility of like patents being taken out by other, adverse, interests. One or more of these benefits may be the dominant motive.

United States letters patent may on proper application be issued to any person if the invention possesses "patentability." A device has patentability if it is *new, useful,* and "inventive" and if it falls within one of the classes of inventions defined in the patent laws. The prescribed classes of patentable inventions include: art, machine, manufacture, composition of matter, and "any distinct and new variety of plant, other than a tuber-propagated plant," which has been asexually reproduced by the applicant. The term "art" by interpretation of court has substantially the same meaning as the word "method" or "process." Examples of "arts" that have been patented are methods of centrifugal casting and methods of manufacturing chemicals. In general, any method which consists of a series of steps in treatment of some material is cognizable by the patent law as proper subject matter of patent. Machines and manufactures cover a fairly obvious field, devices having moving parts being usually designated machines, and those that have none, manufactures, although the line between the two is not hard and fast. Compositions of matter such as plastics, chemical compounds, soaps, and cosmetics can be patented. The classes of inventions patentable are broad but not so broad as to preclude the possibility of the courts' holding that a thing is not patentable merely on the ground that it does not fall within the statutory definitions. For example, the Supreme Court in one case held that oranges coated with borax (to inhibit blue mold) could not be the subject of valid claims inasmuch as coated oranges were not "manufactures."

The requirement that the alleged invention be "useful" does not usually give trouble. Utility, as applied by patent law, does not mean any rigorously high standard of usefulness, but rather that the invention be capable of doing what it is supposed to do. One illustration that has been used to convey what is meant by useful in the patent sense is the match that the patent examiner rejected on the ground that it was inoperative. The story is that the inventor subsequently brought in a box of matches to

demonstrate before the examiner its operability. The inventor endeavored ninety-nine times unsuccessfully to strike a light. Finally the one hundredth match lit. "O.K.," said the examiner. "It's patentable." This story should not be taken too literally.

The requirement that gives the prospective patentee most trouble is "inventiveness," or, as it is more usually termed, "invention." Volumes have been written on the subject. But as yet no objective test or rule of law has emerged. The word invention cannot be defined; nevertheless, the Patent Office and the courts will demand to be shown wherein your proposal "amounts to invention."

Throughout patent history there runs a principle, or philosophy, that is sound in theory but difficult in application, namely, that to grant patents indiscriminately is not in the public interest. The requirement of invention, or inventiveness, is the outcome of efforts to evaluate proposed inventions from the standpoint of their value as contributions to the sum of human knowledge.

Hence, before an inventor can obtain and hold a valid patent he is required to prove that his idea measures up to certain standards of invention. But since there is no objective rule on the matter, the outcome depends upon the opinion of the tribunal judging the case.

The provision in the Constitution of the United States that confers upon Congress power to formulate and enact the laws relating to patents, states in part:

> Congress shall have power . . . to promote the progress of science and useful arts, by securing for limited times to . . . inventors the exclusive right to their respective . . . discoveries.

Accordingly Congress has enacted the patent laws providing that:

> Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant . . . may . . . obtain a patent therefor.

To this provision and law have been ascribed the foundation for the conclusion that the mere fact that a device is novel and useful is insufficient to warrant the granting of a patent; that, in addition, it must possess "invention." One judge put the matter thus:

> In the absence of this element of invention, the patent, if issued, must be held invalid, no matter how novel or useful it may be.
>
> (Smokador v Tubular, 27 F 2d 948)

In order to meet this requirement the inventor is permitted to show, if he can, that his conception or discovery is out of the ordinary. In the Patent Office he may persuade the examiner by advancing arguments contending that the idea is one that would not in the ordinary course of events have occurred to a "man skilled in the art." Or the applicant in the Patent Office may show that his results are unexpected, or that he made his discovery by accident rather than by design.

The courts, in some cases, have gone so far as to require that in order to qualify as being inventive the conception must amount to a "flash of genius." This hurdle, however, is not for the most part as drastic as the use of the word genius would imply. And the Patent Office usually is satisfied if there is some evidence that the stature of the applicant as an inventor is one degree taller than the human yardstick, this fellow "skilled in the art."

If the inventor before the Patent Office can show that he stumbled upon the discovery that is the basis of his invention in a manner analogous, for instance, to the reputed discovery by Roentgen of X-rays, or that the knowledge that he is endeavoring to impart does not follow habitual or logical lines of thought, but just popped out unexpectedly, as it were, he has a good chance of convincing the

patent examiner that his device is patentable.

An argument much used by patent attorneys in behalf of their clients before the Patent Office and the courts is that workers in the art have long been trying to accomplish the particular result of this invention but have failed, and that now applicant has stepped in and succeeded in solving the problem. This angle is sometimes referred to as the doctrine of the "longfelt want."

It is obvious that the prerequisite of "invention" in this view is identifiable as a criterion whereby the tribunals endeavor to evaluate the device from the standpoint of its value to society as a contribution to the sum of knowledge. Since, however, the direct evidence of value at the time the case comes before the Patent Office or the courts usually is a future event, the courts are perforce compelled to resort to indirect evidence, which is less satisfactory than could be desired.

It is clear that in securing patent rights to inventors it is the purpose of the Constitution, as plainly stated in the above-quoted portion, to "promote the progress of science and useful arts." In order to so promote progress, the authors of the patent laws proposed to establish the means whereby a relationship in the nature of a contract could be drawn up between, on one hand, each producer of an advance in "science and useful arts" and, on the other hand, the people, whose representative is the Government. The grant moving to the inventor is his exclusive right to exploit his innovation for a term of seventeen years in whatsoever manner he chooses, but obviously with emphasis on the possibilities for pecuniary profit. The consideration moving to the public is the disclosure of the contribution that the advance represents.

For example: Edison, taking cognizance of the patent laws, devoted his time and ingenuity to the production of new devices, notably, the incandescent lamp. Having produced this invention, he applied for the advantages offered by patent law. The Government thereupon granted to Edison a patent that secured to him the means to control the output for seventeen years. By this grant Edison did not receive any direct reward but only a means whereby he could obtain reward if he undertook to put the incandescent lamp into actual production and succeeded. Presumably, by virtue of exclusive control, Edison derived financial advantages for seventeen years. At the end of this period, the patent expired, the price dropped, and Edison ceased to receive any special profit, but now the public came into full use of cheap incandescent lamps, which, but for the patent laws, they either would never have received or would have received at a considerably later date. This illustration, of course, is oversimplified, but nevertheless describes fundamentally the operation of patent law which justifies its existence.

To be patentable it is not necessary that an invention constitute a long stride forward, nor need it be complicated. The patent law recognizes the virtues of simplicity, and the idea of invention seldom or never involves the idea of magnitude. It is a qualitative, not a quantitative, standard. A small improvement or advance is just as much entitled to patent protection as a large one. It has been held in some decisions that to obtain "absolute simplicity" is the highest trait of genius. Slight improvements are considered patentable, particularly in crowded arts, that is, where many prior inventions have been made. However, although the improvement be small, it still must amount to "invention."

The matter has been explained this way:

Many things appear easy after they have been explained, and doubtless many a man has won-

dered why he failed to think of some apparently simple device or improvement that yielded a fortune to the one who did and revolutionized an industry. The simple fact is that the average person sees things as they are, and he who has originality of vision enabling him to visualize defects and the means of overcoming them should receive adequate reward. (In re Huff, 259 O. G. 386.)

Scientific discoveries as such are not patentable. In one decision the following statement of law appears:

It is well settled, however, that the discovery of a principle or law of nature, however valuable and beneficial the discovery may be to the human race, can never be made the subject of a patent.

This doctrine does not rest on the theory of invention, but on a separate and distinct ground, namely, that patenting of scientific discoveries is not provided for in the law.

Obviously discoveries, such as Newton's formulation of the law of gravity, do not lend themselves to patent protection. Abstract concepts are not subjects of any property rights recognized by law. In the first place, the difficulties of defining the scope of an idea are formidable; second, it is believed by many that even if monopolies in ideas were possible, they would be contrary to public interest.

But the doctrine that scientific discoveries as such are not patentable has been carried rather further than it is possible to explain with entire satisfaction. While one might unhesitatingly agree that the constant of terrestrial gravitation or a new biological discovery lack patentable connotations, it is perhaps not so clear why the discovery of a new method of fumigating plants or of the use of ether to produce anesthesia are types of matters that have been denied protection by the courts. In each of these cases the Patent Office granted patents, but these were subsequently held invalid by the courts.

The basic decision holding scientific discoveries as such unpatentable is that which rendered invalid Dr. Morton's patent on the use of ethyl ether to render the subjects of surgical operations insensible to pain. The conclusion in this case was curiously vindicated by the subsequent revelation that Dr. Morton was not the first inventor, having been anticipated by an obscure German who published his findings on the subject of anesthesia in some out-of-the-way journal four years before. It may be that the judge who invalidated Dr. Morton's patent had actual knowledge of this prior publication, which, of course, would have invalidated the patent on ground of lack of novelty, but no mention of this circumstance appears in the decision. And this decision on its stated premise came to be the precedent for a long line of cases holding the works of creative discovery unpatentable.

It may be worth while, in view of the consideration that recently has been given to amend the law to include scientific discoveries in the category of things patentable, to review briefly Judge Shipman's reasoning in this case. First, Judge Shipman quoted the statute with the observation that to be patentable an alleged invention must come within the statute. He states that his inquiry was whether or not the Morton discovery was the type of thing that was embraced within the scope of the act. He concludes that it was not. He explains as follows:

Very little light can be shed on our path by attempting to draw a practical distinction between the legal purport of the words "discovery" and "invention." In its naked, ordinary sense, a discovery is not patentable. It is only where the explorer has gone beyond the mere domain of discovery, and has laid hold of the new principle, force, or law and connected it with some particular medium or mechanical contrivance, by which or through which, it acts on the material world, that he can secure the exclusive control of it under the Patent Act.

Finally, in order to secure a patent, the inventor must comply with the law in all its formal aspects, in which undertaking the services of an expert in patent law are indispensable. The patent application must be drawn in accordance

with the requirements of the Patent Office and in contemplation of the possibility of the introduction of the document in court.

The application consists of prescribed parts: petition, oath, specification, claims, and drawing. Models and specimens are rarely required. The drawing must be in accord with exacting requirements, with which a patent draftsman is familiar but which are full of pitfalls for the inexperienced. Many chemical cases are not required to have drawings.

The application must be prosecuted before the Patent Office in accordance with fixed rules of procedure. Copies of these rules can be obtained on request from the Patent Office.

In the Patent Office the application is given primary evaluation by an examiner familiar with the particular field to which the invention relates. The course of prosecution rarely runs smooth. Normally, the examiner will raise a great many objections to the case, which it is the business of the applicant and his attorney to straighten out.

The examiner always endeavors to show that the invention is not new. Frequently he is successful. It is a matter of amazement to some inventors to discover that their ideas flourished in minds of prior inventors long dead and forgotten. It is impossible, they feel, that their inventions could have escaped adoption. Yet, while anticipations occur, there also is opportunity for novelty. While it is difficult for an inventor to bring into the world something phenomenally or basically new, it is also fairly difficult to conceive independently something exactly like someone thought of before. The contest usually resolves itself into a question of whether or not the novelty involves "invention."

It is upon comparatively small differences that patentability usually is based. Through the family resemblances of the children of necessity there occur individual variations. The examiner stresses the resemblances; the attorney emphasizes the distinctions.

An indeterminate number of alleged inventions are "knocked out" by attorneys in the course of preliminary searches of the prior art. Sometimes this is very devastating to an inventor, who has staked a great deal on his conviction that he had something new under the sun. One attorney told me of showing a client an exact anticipation of his invention. The balked inventor, an engineer who had invested heavily in the development of the device, was so deeply affected by this discovery that he burst into tears. Of those inventions that survive the first ordeal in the patent attorney's office, and are made the subject of applications filed in the Patent Office, roughly 50 percent are casualties.

When and if at last, after months of battle with the Patent Office, the inventor emerges victorious, what rights does the patent confer?

The patent empowers the patentee, or those to whom he assigns his rights, to sue for infringement, to restrain others from practicing the invention, to issue licenses. Some inventors choose to go into business and manufacture their inventions, but the majority are more interested in either granting royalty-bearing licenses or disposing of their patent outright to some firm.

It is not fair to inventors to hold patents up as royal roads to fortune. A distressing minority pay the inventor as much as one cent. There really ought to be attached to each and every patent that issues from the Patent Office the following warning:

> Inventor, beware! This patent is only a license to sue. It does not insure any monetary reward. It does not vouch for the commercial value of the invention. It may ultimately prove to be not valid. What the courts will do to it is beyond prediction. While you were before the Patent Office we tried to regard you as a benefactor of society. But from now on you're on your own. Allah be with you!

GENERAL SEMANTICS AND THE SCIENCE OF MAN

By CHARLES I. GLICKSBERG

More than ten years have gone by since Count Alfred Korzybski, a Polish mathematician and engineer, published his magnum opus *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics* (Lancaster: Science Press Printing Company, 1933). And although a second edition appeared in 1941, there are still many intelligent people—including not a few scientists—who do not know what general semantics is.

There are, of course, various schools of *semantics:* general semantics as formulated by Korzybski; semantics, or Orthology, as developed by I. A. Richards and C. K. Ogden; sematics, or logical syntax, as set forth by Carnap. Korzybski, in "Psychiatry, Psychotherapy and Prevention" (M. Kendig, Ed., *Papers from the Second American Congress on General Semantics.* Chicago: Institute of General Semantics. p. 95. 1943), explains his use of the term thus:

The word *semantics* is derived from the Greek *semantikos*, "significant", from *semainein* "to signify", "to mean". This term was introduced by Michel Bréal in 1897. Originally, and even today, "semantics" is used for the most part in the sense of the "meaning" of words as defined by words, and the significance of words as affecting human reactions has been neglected. It is true that the two terms "meaning" and "significance" somehow overlap, with a resulting confusion and difficulty of analysis. We use the term "general semantics" in preference to the old "semantics" to indicate a fundamental difference between the two. The older difficulties originated because specialists in the "meaning" of words disregarded an unavoidable factor; namely, that any linguistic or mathematical theory must begin with undefined terms which cannot be defined any further by words. In principle these *undefined terms* are labels for direct experiences and observations which involve subcortical processes on the *silent* (*un-speakable*) *level.* Obviously no amount of verbal definition can convey to the individual first order pain, which he has to *evaluate* on the silent, organismal level inside of his skin.

General semantics, therefore, attempts to employ scientific knowledge and the scientific method as an aid to sane living. But how can this be accomplished when each science is technical and specialized, dealing as thoroughly as possible with some isolated aspect of a more inclusive whole? As formulated by Korzybski, general semantics proposes to put an end to this atomization of scientific knowledge and scientific thinking. Science must be both humanized and synthesized. If we are to lead lives that are rational, well-ordered, instinct with meaning and purpose, we must have an adequate picture of "reality" and we cannot draw that picture without the aid of a science which will coordinate and unify the various other sciences. Whatever synthesis we arrive at will be provisional. New knowledge is created at every moment in the dynamic space-time continuum. The scientific synthesis is therefore perpetually unstable, subject to incessant revision. That is why it becomes necessary to "date" our knowledge and the beliefs we base on this knowledge.

Yet scientific knowledge must be applied if it is not to remain abstract and sterile. The supreme task of twentieth-century man is to utilize the knowledge he already possesses in such abundance and apply it to the end of personal and social happiness. Judged from this point of view, general semantics has much in common with scientific humanism. It levies heavy tribute upon every

science, from astronomy and higher mathematics to dynamic logic, psychiatry, anthropology, medicine, and colloidal chemistry, in order to build up a science of man. What it attempts to do is to train people in the consciousness of abstracting and in the proper method of evaluation. They must stop identifying words with things; they must also realize that they live in a four-dimensional world where every point in space has a time-coordinate. The universe of matter is constantly undergoing change; it is dynamic, whereas many of our linguistic counters and conventions are static. We must endeavor to make our language similar in structure to the facts it is designed to represent. The facts must come first, then the words and the definitions, the theories, interpretations, and philosophies. That is the *extensional* method of science. General semantics as a methodological discipline can free us from the prison that linguistic habits and unconscious assumptions build for each one of us.

Count Korzybski was quick to realize that education was fundamental if the semantic reactions of the oncoming generations were to be properly trained. Unfortunately, a majority of teachers, Korzybski charges, are at present largely ignorant of "modern science, scientific method, structural linguistic and semantic issues of 1933. . . ." Korzybski's aim is to educate the new generation to make the difficult transition from Aristotelian and Newtonian to non-Aristotelian and non-Newtonian systems. The goal is not intellectual understanding alone, but a transformation that will affect the organism-as-a-whole. The important thing is to "extensionalize," to look first at the facts, to learn something about the structure of the world, which is the only source and content of knowledge. General semantics is thus a generalized scientific methodology. Scientific thinking is not to be reserved for the lecture hall or the laboratory; it is to become a habit, a series of neurosemantic adjustments to the facts of life, a method of evaluation which will promote survival values at the highest human level.

General semantics in education will not come into its own until teachers make the effort to grasp what general semantics attempts to do, how it does it, and what, under the proper conditions, it can accomplish. It took a long time for science to find a place for itself in the curriculum, and science teaching even now, though it is highly successful in various specialized fields, is failing to achieve what should be its primary objective: the training of the young in scientific thinking so that it becomes as habitual as cleanliness or social politeness. Increasingly the demand is being heard that the basic science course should be required of all students, and that it should be integrated into the secondary school curriculum. That consummation, however, will not take place until the scientific attitude permeates every possible phase of the curriculum. The student as well as the teacher must cease to think of it as a departmentalized unit of instruction: so much technical subject matter to be assimilated in a given course. Here the methodology of general semantics can come to the rescue by humanizing the findings of science and applying them, in a language specially suited to the purpose, to the complex area of social and personal living.

The mistake of those who not so long ago propagandized the schools in behalf of propaganda analysis was that they made doubt an end in itself. Abstractions were to be distrusted because they might be, and often were, employed for evil purposes. General semantics avoids this danger by pointing out that language, though it can be abused, can also be used for effective adjustment to reality. Words are not fixed entities; they are dynamic, chameleon-like creatures

influenced by their contextual environment. They are shaped and colored by the organismic events that precede their emergence. They do more than state facts or single out objects for our attention: they also suggest; they evoke moods; they compose the substance of poetry and prayer.

Words admirably illustrate the theory of relativity. The same word may be multiordinal in nature; it may refer to a single aspect of a manifold of meanings. Light is meaningless apart from darkness; night from day; no from yes; strength from weakness; health from disease. Which aspect of meaning is in question is determined by the context. Language manifests the relativity that is observable in human knowledge. For Nature too is dialectical; things are not solid entities but streams of energy that merge with other streams and appear qualitatively different. Language must reflect this protean and dynamic character of the world.

Language, like the world itself, is constantly undergoing change. If words change in meaning, it is because men change. The dictionary can be of only small help in the search for meaning, except in the sciences, where the meaning of words is stabilized. The dictionary contains but the dead bones of language. Words are not isolated units that can be taken apart, defined, and then pieced together again. The general semanticist tries to make the young realize that words are not things. They are but symbols: maps representing some territory. There are good maps (which enable us to reach our goal) and bad maps (which represent territory never seen on land or sea). Hence we must learn that words mean what we make them mean in a given context. The same word may change its meaning from one sentence to another and even within the selfsame sentence. What is more, if words are symbols, then there are words for which there are no referents in reality: unicorns, griffins, and square circles. Conversely, there are things in reality for which there are no words.

Thus the process that determines the relation between an object or event and a word is extremely complex. The analysis of linguistic usage is no academic matter; it leads inevitably into a discussion of how we know that we know. What is the bond that obtains between verbal symbols and nonlinguistic objects and occurrences? How do we arrive at *meaning?* Furthermore, if words are not things, it follows that they communicate only a highly selected and condensed portion of experience, the part that is focused. No matter what we say about an object or event, something has been left out. That is why language, however detailed and precise in its description, does not exhaust the nature of reality. The important thing is to establish some sort of valid connection between word and object, between object and word. That is to say, language must be "extensionalized." Finally, since words are general, the correspondence between a statement and the experience it represents cannot be quite exact. Bertrand Russell says in *An Inquiry into the Meaning of Truth* (New York, 1940): "There is no point in the growing precision of our language beyond which we cannot go; our language can always be rendered less inexact, but can never become quite exact."

General semantics is concerned with language because language is a vitally important, man-made instrument for helping man to adjust himself to his environment. Adjustment to reality, through language, involves more than the command of a large vocabulary; if that were the case, lexicographers like Samuel Johnson would approximate our ideal of human excellence. No, language as a means of proper adjustment to real-

ity is inescapably associated with the use of dynamic logic. Most books on formal logic tell us how to think, concentrating on method to the exclusion, for the most part, of significant content. The implicit assumption of course is that if we know *how* to reason correctly, we will infallibly hit upon the right conclusions. General semantics demonstrates that this is a *non sequitur*.

And yet there has never been a more crying need for disciplined thinking. There is no reason why logic—dynamic logic—should remain abstract and theoretical. If it is to be dynamic, it must educate "the mind," and the best way of doing that is by attacking entrenched dogmas and popular fallacies and prejudices and exposing them to the light of day. Exercises of this kind are an excellent method of validating the scientific method in action.

We must come to understand that there is an advantage in having many hypotheses competing with one another for our acceptance. In this way, more and more facts are disclosed that must be accounted for. Even the scientifically trained eye observes only a part of all that there is to be seen. Judgment based on *all* the facts is an ideal that science cannot hope to achieve. Its data can never be altogether complete. It is therefore better to entertain a plurality of theories, each of which will demand that we order our facts within the required framework. This puts an end to the two-valued system of orientation: right or wrong, either-or. An infinite-valued orientation makes it clear that no hypotheses are absolutely certain; they possess a degree of probable truth ranging from zero to one hundred percent. Invariably it is a question of more or less; that is the best we can hope for.

General semantics, like science, pictures a problematical universe in which even stubborn, irreducible facts prove to be strangely elusive. They are changeable and subject to correction. A scientific logic consequently trains the young not to have any excessive faith in "facts." It is a superstition, Professor F. C. S. Schiller tells us, "that 'facts' are plain, straightforward, and easy to discover; they are often subtle and recondite and relative to circumstance, changing their aspect to suit their scientific environment like any chameleon." If facts are thus subtle and recondite and changeable, it is not surprising to find that words, too, are caught up and borne along on the tidal sweep of change. The recognition of the instrumental value of words and the role they play in precipitating meaning will help, as Schiller points out, to safeguard us against "the terrible verbalism to which logic has been enslaved!"

General semantics can arm us with potent weapons in the fight against this "terrible verbalism." It has worked out a number of devices (they are no more than that) which can teach students how to counteract the elementalism inherent in traditional language. These are the devices of indexing, dating, the use of "etc.," the hyphen, and quotation marks. If each thing in dynamic nature is unique, complete sameness between any two things does not exist. If language is to be similar in structure to the world it endeavors to represent, it must index its statements and thus achieve an infinite-valued orientation. Smith_1 is not like Smith_2; Negro_1 is not like Negro_2. It is also necessary to cultivate the systematic use of the device of dating statements. The Germany of May 1946 is unlike the Germany of May 1940. To reinforce the attitude of non-allness, it is wise to use "etc." to make it clear that not everything has been said. The hyphen is a linkage device, as in "space-time," to overcome the elementalism that haunts our use of a language still dominated by Aristotelian categories of thought. Quotation marks are merely

warning signals to the reader to beware of the way in which a word is being used. The general semanticist would enclose "mind" and "consciousness" in quotation marks because there are no such separable entities in the human organism.

Not one of these devices, if properly explained, is beyond the grasp of the high school adolescent. To teach them as principles, however, and to establish them as ingrained habits are two different things. One relies principally on verbal mastery, the other depends on assimilating the method and the material so thoroughly that in the future we do not jump hastily to conclusions or act impulsively. A kind of automatic neurological delay is effected.

Another advantage in the teaching of general semantics is that the student uses himself as a guinea pig: his experiences constitute his laboratory material; he makes his own scientific discoveries and applies them to problems with which he is personally familiar. In this way the "course of study" remains perpetually fresh and challenging and new. There are no rigid boundary lines, no compulsory textbooks. Take the device of non-allness. As an abstract principle it can be "taught," copied down in a notebook, and memorized in a few minutes. Nothing is gained thereby. The student persists in his old ways, like the sinner who backslides after listening to a soul-stirring Sunday sermon. He has only acquired another bit of interesting but useless information. The device should be withheld until the very last. Only after the student has worked out the application should the idea be driven home. The first step in applying the device of non-allness is to consider what a "fact" is—a most complicated procedure. Philosophers have spilled Niagaras of ink over this highly complex and controversial issue. When is a fact a fact? How do we know a fact when we encounter it?

"This pencil" (holding it up for the class to see)—"is it a fact?" Certainly. Well, how does one prove that the pencil "is"? The senses are our telltale reporters. We depend on them to help us understand the world of things aright. But do not the senses often deceive us? Sometimes we see things that are not there and hear things said that are not spoken. Witnesses are notoriously unreliable in their testimony. Neither the eyes nor the ears nor the other senses are perfect registering instruments. What we do is to verify our impressions by comparing them with those of other presumably qualified observers. Thus we obtain a sort of working agreement.

Even at that, "the fact" is still conjectural, an opinion, and not an ironclad, indubitable reality. Scientists have frequently emphasized this point, namely, that our postulation of a reality outside of us is a hypothesis and nothing more. We accept it as valid for the simple reason that it does not as a rule play us false. When we do not go wrong, we assume that our hypotheses concerning reality must be correct. Sometimes, however, our senses are not acute enough to perceive a "fact." How do we detect microbes, viruses, vitamins, electrons? We cannot see them, touch them, smell them, hear them. What we do is to devise scientific instruments which are, as it were, extensions of our five senses. They make recordings of what is happening on the microscopic and submicroscopic level. They furnish important evidence of what would otherwise remain unknown. Then we interpret this evidence and obtain a rough approximation of what a fact is—nothing but a conventional agreement.

The world of reality has now been disintegrated, broken down from its pulsating actuality and organic wholeness. A pencil mirrors the state of the universe in flux. The terrible doubt of appearances has overcome the student and he is

no longer the same. He begins to question, to analyze, to look behind the veil of solid, substantial reality. To the uninitiated who depend on common sense this may seem very much like quibbling. What difference does all this make?

It makes a great deal of difference. Our understanding of the world and of ourselves, our interpretation of reality, hinges on the determination of this issue: When is a fact a fact? How do we know that we know? Even if convinced that the methodology of general semantics does make a difference, the doubting Thomas is apt to ask what he considers a disconcerting question: "Can it be taught?" That is the question, usually with damaging implications, which often meets the proposal that general semantics be made an integral part of modern education. The only effective way of answering this question is with a *fait accompli*. When Alice asked, "What *is* a Caucus-race?" the Dodo, the reader will recall, replied : "Why, the best way to explain it is to do it." Which is, by the way, an excellent example of general semantics in action, even if the Dodo had never heard of it.

To come back to the device of non-allness. Our language is shot through with the assumption of "allness." There is a tendency, too, to strengthen our case, whenever we generalize, by making it universally applicable. Writers of advertisements will say, "All women are wearing this style of hat now." There used to be an old popular song which began: "Everybody's doing it." Proverbial expressions, the homely wisdom of common sense, testify to this linguistic habit. If, however, we extend the device of non-allness to other areas of experience, its significance and range of application become much clearer. One sin does not make a sinner. One crime does not make a confirmed criminal. One disappointment in love should not make us condemn all women as two-faced. A number of disillusioning encounters with the worst characteristics of human nature—selfishness, treachery, baseness, corruption—should not lead us to conclude rashly that all human nature is essentially vile.

The aim of general semantics, once more, is not to make students suspicious of the uses of language. They are not trained to hunt for a fallacy lurking in every statement. What it does is to provide them with exercises which will make them realize the nature of language and thus be forewarned and safeguarded against the abuses to which words can be subjected. They are not left with the dismal feeling that all language is a trap, that its main purpose is to betray, that all discourse is a species of cunning propaganda. No, language is meant to serve as a map.

General semantics seeks to make this linguistic map correspond as closely as possible in structure to the territory it is supposed to represent. After a time, students trained in general semantics derive considerable amusement from spotting "loaded" words like "globaloney," "Jew Deal" for "New Deal," "crackpot," "freedom of enterprise," "utopian," "radical," and "red." They enjoy studying the art of verbal camouflage as it functions during wartime. On September 26, 1943, the *New York Times* printed a release from the Office of War Information, which listed thirty different ways employed by the Germans to disguise the unpalatable facts of retreat. These propagandistic alibis from the German military lexicon make fascinating reading: retreats become "planned withdrawals," "defensive successes," "successful disengagements," "unencircling maneuvers," and so on.

The most beneficial lesson that general semantics has to teach deals with the consciousness of abstracting. What Korzybski emphasizes again and again in *Science and Sanity* is that we cannot

open our mouths without abstracting, and that it is to our interest, if we wish to lead sane lives, to become conscious of this process. Geometry, for example, deals with the abstractions of actual things in the world. The only difference between these abstractions and those fathered by the celebrated man in the street is that the former are exact and the latter are approximate. With exact abstractions we can gradually secure mastery over our environment. With loose, makeshift abstractions we not only make serious blunders but also bring about costly nervous maladjustments. What distinguishes man from the animals is precisely this power to abstract.

If abstractions are fundamental to the business of sane living, it is essential that we learn how to use them intelligently. Talking about language is futile. It only serves to confuse. It is better procedure to take some text with which students are already familiar and which they think they understand. For example, what does the saying, "All men are created equal," mean? What are the facts? Are men equal physically, financially? In skill, strength, talent, beauty, intelligence, length of life? Decidedly not. Then what does the phrase mean, if it means anything? Are the runners before a race equal? Are all students in the classroom equal? Gradually students learn that there are no absolutes, no hard-and-fast oppositions. A thing is not either good or bad, equal or unequal, superior or inferior, right or wrong. Such two-valued orientations are false to fact.

Where general semantics is to be taught is a problem that can best be decided by experimental practice. It has been applied with notable success in such fields as English, public speaking, mathematics, and even medicine. Where it is most needed and where it will probably achieve the greatest measure of success is in the teaching of science on the secondary school level. The habit of scientific thinking and a corresponding mastery of language as a man-made instrument—if general semantics can bestow these twin gifts on the young there is no reason why it should not be incorporated in the curriculum, no matter how "revolutionary" such an innovation may seem to the upholders of the educational *status quo*.

CONSIDERATIONS IN REGARD TO TAX CAPITALIZATION

By CARL F. WEHRWEIN*

THE burden of some taxes does not remain upon the persons or concerns who turn the money over to the government but is shifted by them to others. The burden of a new tax levied upon a merchant, for example, is shifted to his customers if he, because of the tax, raises the prices of the goods he sells. A merchant may not in every case of an increase in his taxes be able, however, to raise the prices of the goods he sells because his customers may, owing to the availability of acceptable substitutes sold by other merchants, refuse to pay the higher prices. The taxes levied upon property which endures either perpetually or for a long time (land or land and substantially built buildings) are sometimes shifted by the process of capitalization. This can occur only when such property is sold, and the taxes which it is expected will after the sale be levied upon the property are shifted from the buyer to the seller. In brief, this is done through the sale price, the price being lower than it would be if no taxes were going to be levied. The fact that the taxes reduce the capital or sale value of the property is the reason the term "capitalization" is applied to this method of shifting. In connection with every tax, the question of its incidence—the person or group upon whom the burden will finally rest—naturally is of great importance.

Much has been written about the capitalization of taxes, particularly in connection with the taxes levied on land, but there still is considerable confusion and difference of opinion in regard to this process. I shall try to show clearly (1) that in spite of the capitalization which takes place, the burden of all the taxes levied on land (in this discussion the term "land" should be understood to mean real estate,—that is, land and buildings) is borne by the landowning group, and (2) that some of the capitalized taxes do not stay capitalized.

It is generally agreed that in the cases of certain sales of land the taxes which are later levied on the property are not capitalized. In general, if land is sold when the market is a sellers' market, the purchasers cannot capitalize the taxes which will thereafter be levied on the property. In a sellers' market, the sellers are in an advantageous position as compared with the buyers—the demand for land is high, and the amount for sale is relatively low. A good illustration of a sellers' market is the period of the farm land boom which followed the first World War. Of course the burden of all land taxes which cannot be capitalized when the property is sold is borne by the purchasers, assuming that they cannot shift the taxes in some other way. In the cases of certain other sales of land, however, the taxes subsequently levied on the property are capitalized. In general, if land is sold in periods of buyers' markets (the opposite of sellers' markets), the purchasers of the property are able to capitalize and thus shift to the sellers the future taxes which will be levied.

It has been loosely argued that to the extent of the land taxes which are capitalized, the burden of this type of tax is

* Dr. Wehrwein is Chief of the Food Programs Division, Office of Foreign Liquidation Commissioner, State Department. The views expressed in this article are his personal views and are not necessarily those of the State Department.

lighter than has been claimed, and that complaining about the burden insofar as it involves these particular levies is not justified. This of course is true as far as the landowners whose taxes have been capitalized are concerned. However, it must be remembered that the process of capitalization of taxes on land consists merely of the shifting by the purchasers of such property of the taxes which will subsequently be levied on it to the sellers, who are other members of the landowning group. The sellers who after the sales have been made still own some land continue to be members of this group. However, even the sellers who after the sales no longer own any land should, as far as the taxes shifted to them by capitalization are concerned, be considered still to be members of the group, because it can be assumed that the losses they thus sustained came out of the wealth or assets they accumulated in the process of the ownership and operation of the land sold. Hence, the burden of all the taxes levied on land is borne by the landowning group (assuming that the taxes are not shifted to others by some method other than capitalization), and the arguments that have been advanced to the effect that these levies are excessive cannot, as far as these property owners as a group are concerned, be qualified by any claim of part of the burden having disappeared as a result of its capitalization. Of course, as between the members of the group, the burden may be inequitably distributed.

Professor Harold M. Groves has claimed (*Financing Government*, New York: Henry Holt. p. 123. 1939) that if land is purchased under circumstances favorable to tax capitalization, the purchaser "buys free of and capitalizes only the differential tax burden on the particular as compared with alternative investments" (the excess, if any, in the taxes on the land above those levied on alternative investments). Groves repeats this argument at another place (p. 150), as follows:

> It should be remembered . . . that capitalization and shifting even under the most favorable circumstances do not entirely absolve the taxpayer from burdens. Capitalization relieves only to the extent that taxes on one investment are higher than those upon others.

It would appear that this would be true only if the taxes on the alternative investments could not be capitalized. The future levies on land purchased can be capitalized to the extent of not only this differential but also the capitalized taxes on the other possible investments.

However, my main point is that certain capitalized land taxes do not stay capitalized but by a psychological process revert to the purchaser of the property. Let us suppose that a farm is sold and the conditions are such that the taxes which will thereafter be levied on it are fully capitalized. Let ten years go by. Will the purchaser still claim that he is not bearing the burden of the taxes currently being levied upon the farm? I do not think so. He will by that time be complaining about taxes as much as anybody else. He will have shifted his psychological base in regard to those taxes. There are two reasons for this change in his attitude. In the first place, the money which he will be turning over in payment of the taxes will be money that he has earned by his own efforts in operating the farm. In the second place, the fact that those taxes were capitalized when he purchased the farm will have faded into the distance, and, if he has not already forgotten all about that fact, it will have become so hazy as to appear unrealistic to him and can no longer serve as a sound basis for his views regarding the taxes being levied on the farm. Hence, the burden will seem to be resting on him.

Similarly, the seller will after the expiration of the ten years no longer be feeling that he is bearing the burden of the

taxes currently being levied upon the farm. During all the time since the sale he will not have been taking money out of his pocket to pay the taxes on the property, and the loss he sustained in the capitalization process will have pretty well faded out of his memory. It will seem remote and impersonal to him, and he will have stopped considering it in formulating his views regarding the taxes he is currently paying.

Certainly most buyers and sellers of land in the cases in which the new ownership situations created continue to exist for a considerable period of time undergo these changes in attitude toward the capitalized taxes. This is, therefore, for all practical purposes a general situation. It may be argued that, though land taxes may not stay capitalized in a psychological sense, they must actually remain capitalized in an economic sense. But if they do not stay capitalized in a psychological sense—that is, if, on the one hand, the owners of land after the expiration of a period of years generally become convinced that they are bearing the burden of the taxes, and, on the other hand, the last sellers of the land, after the same period of time generally feel that they are no longer bearing the burden, and if all other people, including politicians and lawmakers who may pass laws upon the basis of this view in general agree with them—do the taxes stay capitalized in the economic sense? I do not think it would be realistic to say that they do. During this period of time the owners and the last sellers will have adjusted all their related economic circumstances to, or built them up on the basis of, this view.

This change in attitude on the part of the buyers and sellers of land toward capitalized land taxes is natural and normal. The same type of thing happens in connection with unsecured debt, especially if the amount involved is relatively small. This is the basis of the statutes of limitation regarding debt. These statutes provide that if no part of an unsecured debt or of the interest thereon is paid, or the borrower does not in some other way reacknowledge the debt within a certain period of time, the debt is "outlawed," and the legal claim of the lender against the borrower terminates. These statutes are based upon the fact that if no part of an unsecured debt or of the interest thereon has been paid within a certain time, the lender has abandoned his claim; he has in his own mind written the debt off; he has fully adjusted himself to the nonrepayment of the money. Here, then, is another instance of the acceptance with the passage of time of certain circumstances as being permanent or realistic which had originally been expected or understood to be temporary or unreal.

Hence, it appears that the capitalization of land taxes is only a temporary phenomenon. Taxes levied on any land, if they are capitalized at all, remain capitalized only during a certain period of time, and at the expiration of that period the burden reverts to the purchaser. Groves also touches on this in a discussion of the capitalization of taxes on farm land, as follows (p. 150):

> . . . much farm land remains for many years in the possession of a single family. Of the 3,800,000 farm operators who owned their farms in 1935, about 44.5 percent had been operating their farms for a period of 15 years or more. . . . Insofar as farmers retain their farms, . . . the capitalization process does not operate.

What is true of land taxes in this regard is in general, for the same reasons, also true of taxes levied upon other types of tangible property.

Economic theory should not be made to be more logical or consistent than human beings or their economic activities themselves are.

SEEING SUMMER SOUNDS

By W. H. PIELEMEIER

DEPARTMENT OF PHYSICS, THE PENNSYLVANIA STATE COLLEGE

FROM midsummer to early autumn there is a wealth of outdoor sounds that we have scarcely dreamed of until we have made a conscious effort to listen for them. The human ear is a remarkable acoustic instrument. However, the average person cannot tell the pitch nor the loudness level very accurately without some form of detecting meter to make the sound *visible*, as it were. Some of the "sounds" may even fall outside the frequency range of 16 to 16,000 cycles per second that can be heard by the average person with good hearing. A few people can hear 22,000 cycles per second if the intensity is large enough.

On August 14, 1945 (V–J Day), I was using a General Radio Sound Level Meter to measure the intensity level and the loudness level of sounds produced by insects in my flower garden. When the State College V–J celebration was well under way, its intensity level was measured and found to be about 70 decibels at $\frac{3}{4}$ mile from the business district. The level for ordinary indoor conversation is about 60 decibels (Fig. 1). To carry on a conversation through this V–J noise, the speech level had to be raised to 75 or 80 decibels. At half the above distance, ($\frac{3}{8}$ mile) the V–J noise was probably about 76 decibels.

The intensity level of a sound is measured in decibels, and the intensity itself is measured in watts per cm^2. The level is said to be zero decibels for an intensity of 10^{-16} watts/cm^2. A 1,000-cycle note of this intensity is at the threshold of hearing (just audible) for a person with acute hearing. Ordinary conversation (60 db) represents 10^{-10} watts/cm.^{2}, which is one million times the threshold intensity. Ten decibels are added to the intensity level each time the intensity at the ear or the power of the source is multiplied by ten. The loudness, or noise, level is measured in phons by adjusting the loudness of a controlled 1,000-cycle sound to an equal loudness as judged by an observer. Then the loudness level in phons of the first sound is said to be equal to the adjusted intensity level in decibels of the second sound. The unit of loudness level is sometimes called the decibel also, but the loudness level of a sound in phons and its intensity level in decibels are not in general the same. They are equal, however, if the sound is a 1,000-cycle note. At 35 cycles per second, the threshold loudness (zero phons) corresponds to about 63 decibels (Figs. 1, 2).

Some of the bombing in the recent war was accomplished by radar without even a glimpse of the target. Bats avoid obstacles in the dark by means of sound waves whose frequency is too high to be heard by man. In a somewhat similar way in a dozen or more cases I have located slender meadow grasshoppers, *Conocephalus fasciatus*, by means of a meter for high-frequency sound waves. Both long- and short-winged species were located. Both are long-horned. Before it was known that these grasshoppers produced 40-kilocycle sounds, I was exploring with the meter in a general way when at a certain spot the meter deflected strongly. The spot could be located to the nearest 2-foot cube, but no insect was found. On the second afternoon nearly the same spot was located in the flower bed, and again no insect could be found. On the third afternoon a more cautious procedure

located the insect to the nearest few inches, and then it was seen. Its color matched that of the plant on which it sat, and it managed to keep almost hidden by the plant. In each case, maximum deflection of the meter occurred when it was tuned to 40 kilocycles per second. The intensity level 4 to 6 inches from the insect was about 75 decibels. Because there was also a smaller deflection at 20 kilocycles per second, an as-

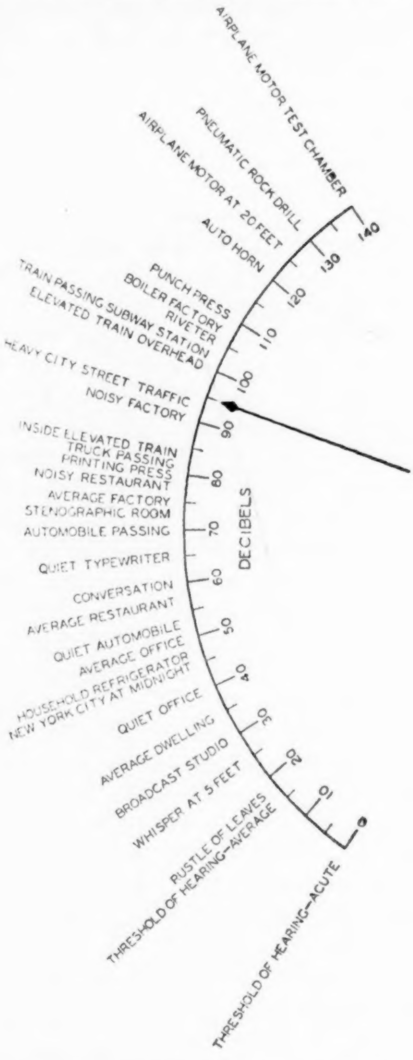


FIG. 1. INTENSITY OF NOISES
TYPICAL NOISES AS MEASURED IN DECIBELS.

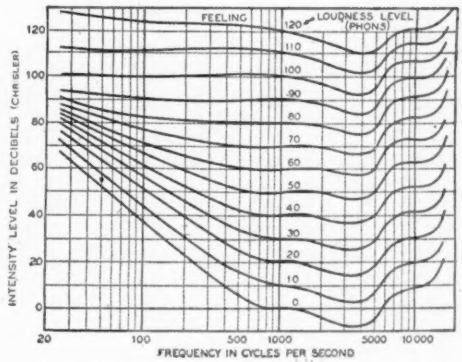


FIG. 2. FREQUENCY vs. INTENSITY
EQUAL-LOUDNESS CONTOURS FOR AVERAGE EAR.

sistant whose hearing range extends to 22 kilocycles per second was called to listen. He could hear the 20-kilocycles-per-second component quite clearly and also a weak sound of lower frequency. Then the grasshopper was caught. It was identified as *Conocephalus fasciatus* by Professors S. W. Frost and V. R. Haber, of our Department of Zoology and Entomology. They also identified the others named herein.

Later tests at several distances showed that the greatest intensity level in the 40-kilocycle band was 86 decibels at a distance of 10 cm. Long (*fasciatus*), intermediate (*gracillimus*), and short-winged (*strictus*) species of *Conocephalus* were tested. The output of the last excelled by 1 or 2 decibels—probably because the movement of its shorter wings is resisted less by the air. Since these grasshoppers are less than ¾ inch long, the inverse square law of intensity versus distance held in the range 3 to 6 inches. Beyond 1 foot the excessive absorption and ground reflection caused deviations. Dozens of tests showed that results could be duplicated to within 2 decibels. If our ears were as sensitive to 40 kilocycles as they are to 3 or 4 kilocycles, we could hardly carry on a conversation if several of these slender meadow grasshoppers were singing in our midst.

Since the slender meadow grasshoppers must be nearer than 3 feet to be heard by people with acute hearing, it is difficult to locate them by means of their audible sound. This sound accompanies, and is timed with, the supersonic (high-frequency) components, which cannot be heard by anyone. I found that a few of the larger species of the long-horned grasshoppers, which can be heard at distances of 40 feet or more, can also be detected at close range with the supersonic meter. One of these is *Neoconocephalus ensiger* and another is *Orchelimum vulgare.* The latter can often be found at the edge of cornfields. It frequently sits on the corn tassels and sings, "Tip, tip, tip, tseeeeeee." In neither case was there an output peak beyond 20 kilocycles per second. The response of the meter diminished consistently as it was tuned to higher frequencies. The slender meadow grasshopper, *Conocephalus fasciatus,* stridulates in about the same manner, but the audible part is much weaker, and the supersonic part is very intense at 40 kilocycles per second (76 db at 1 ft.).

It was suspected that the weak sound of 67 cycles per second from *Orchelimum vulgare* was produced by the scissors-like action of the wings. If so, one would expect the scraper on the right wing to go back and forth 67 times per second across the file on the under side of the left wing. (Of course the file would go through a similar motion.) When a strobolux was secured, the same grasshopper was no longer at hand, but another of the same species was tried, the frequency of the light flashes being varied over the range from 50 to 70 per second. As the rate approached 60 per second, the wings appeared to slow down. The stroke was about 1 mm. At 60 flashes per second, the motion was frozen. Another grasshopper of the same species was tested with the sound analyzer. A peak was found for it at 58 vibrations per second. Another was tried with the strobolux and was found to make 61 vibrations per second. This is conclusive evidence that the wings of this species work back and forth about 60 times per second during the few seconds of stridulation. The 7.3 and 14 kilocycles per second are probably resonance frequencies of small sections of the wings. The tympanum probably produces the intense 14-kilocycle sound.

EVAPORATION REGIONS IN THE UNITED STATES

By STEPHEN S. VISHER

PROFESSOR OF GEOGRAPHY, INDIANA UNIVERSITY

The rate of evaporation of water is an environmental influence of major importance and merits continued study. Several prolonged investigations of local and regional differences in evaporation have been made by biologists. The accompanying maps present some recent data, chiefly gathered by nonbiologists, which supplement earlier studies in significant ways. This is my tenth article in The Scientific Monthly on various aspects of the climate of the United States.

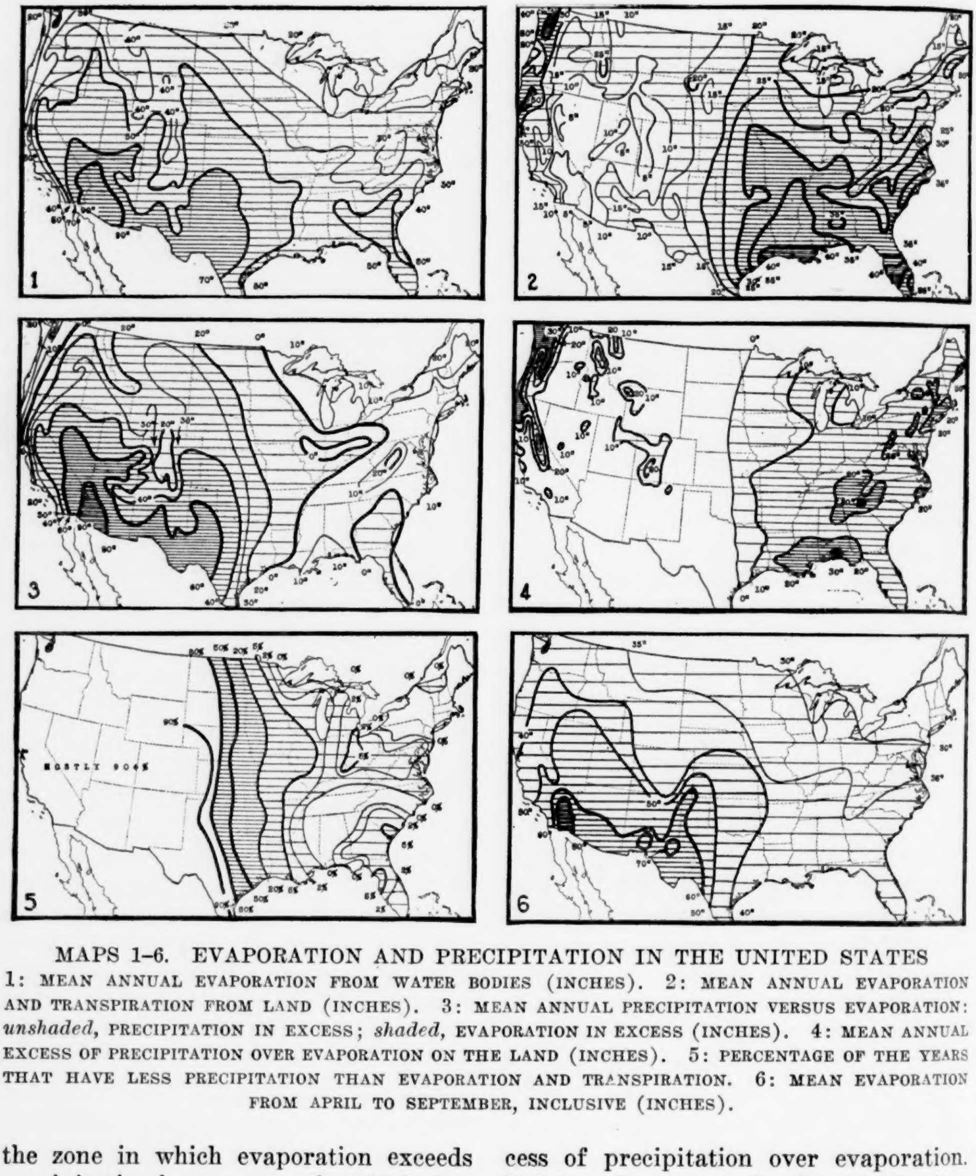
Map 1 is a somewhat simplified, shaded copy of a map published in 1942 by Adolph Meyer, the distinguished hydraulic engineer, of the annual loss by evaporation from shallow lakes and reservoirs.[1] It shows a southwestward increase from the Great Lakes, where the loss is about 20 inches a year, to the lower Colorado River Valley, where the loss is more than 90 inches. The North Pacific Coast also loses less than 20 inches a year, while much of Florida and Georgia loses more than 50 inches.

Although the coldness of Western streams and lakes is commonly ascribed solely to melting snow at their sources, it must be attributed in part to rapid evaporation. The cooling effect of evaporation helps to explain the occurrence in Western streams of trout that require cold water. The relatively small amount of evaporation in the Northeast permits many streams and lakes to exist even though the precipitation is not large. Conversely, despite an annual rainfall of more than 50 inches in the Southeast, many streams shrink badly in summer.

Map 2, a shaded copy of a 1938 map by Kittredge, shows the annual water loss due to transpiration and evaporation.[2] This map shows only a small loss in the Southwest, although reservoirs and other water bodies there lose heavily (Map 1). In this arid region there commonly is little water available for transpiration from vegetation or evaporation from the soil. Instead, the ground dries out deeply, and the vegetation is characteristically xerophytic, with remarkable moisture-retention. This map shows that the greatest losses are in the Southeast and in parts of the Northwest. This map resembles one of average annual precipitation much more closely than does Map 1.

Map 3, after Adolph Meyer, shows the difference between mean annual evaporation and precipitation. Heavy zero lines mark boundaries where, on the average, evaporation equals precipitation. One such line is situated not far from the Mississippi River, another extends from central California to north-central Washington, and a third lies in the Southeast. In most of the eastern half of the country the difference between annual precipitation and annual evaporation is less than 20 inches, but in much of the Southwest evaporation is more than 60 inches a year greater than precipitation. Conversely, in the Northeast and Northwest, precipitation is 10 to 20 inches or more greater than evaporation.

The unshaded area, where precipitation exceeds evaporation, is well forested whereas the shaded area, in which evaporation exceeds precipitation, ranges from subhumid prairie to desert. Roughly,



MAPS 1–6. EVAPORATION AND PRECIPITATION IN THE UNITED STATES
1: MEAN ANNUAL EVAPORATION FROM WATER BODIES (INCHES). 2: MEAN ANNUAL EVAPORATION AND TRANSPIRATION FROM LAND (INCHES). 3: MEAN ANNUAL PRECIPITATION VERSUS EVAPORATION: *unshaded*, PRECIPITATION IN EXCESS; *shaded*, EVAPORATION IN EXCESS (INCHES). 4: MEAN ANNUAL EXCESS OF PRECIPITATION OVER EVAPORATION ON THE LAND (INCHES). 5: PERCENTAGE OF THE YEARS THAT HAVE LESS PRECIPITATION THAN EVAPORATION AND TRANSPIRATION. 6: MEAN EVAPORATION FROM APRIL TO SEPTEMBER, INCLUSIVE (INCHES).

the zone in which evaporation exceeds precipitation by not more than 20 inches is subhumid and mostly a prairie; wherever the difference is more than 40 inches, aridity generally prevails, and scattered shrubs, with little grass, are characteristic. The dominance of evaporation in the West makes for salt lakes and saline or alkaline soil, with significant ecological responses.

Map 4 also depicts average annual excess of precipitation over evaporation. It is based on a map by Hoyt,[3] who is a specialist on water supply of the U. S. Geological Survey. It differs radically from Map 3 because it deals with the land, whereas Map 3 deals with water surfaces. The zero line of Map 4 lies near the western margin of the tall grass prairie or black-earth soil region. To the west of that line, the unshaded areas normally have no annual excess of precipi-

tation to leach soluble minerals from the soil. Hence an excess of minerals is usually present in Western soils, which are classed as pedocals, because lime is abundant. Conversely, in the Northwest, South, and East, where precipitation exceeds evaporation, there is much soil leaching, and lime and most other plant food minerals are inadequate.

Map 5, also after Hoyt, shows the percentage of the years which have less precipitation than an amount sufficient to meet the demands of evaporation and transpiration. It shows that in about half of the East precipitation is normally greater than evaporation and transpiration. Indeed, in parts of the Northeast and Southeast a deficit in precipitation occurred in less than 2 percent of the years studied. West of about the hundredth meridian, however, more than half of the years have a deficit, and in most of the West, nine-tenths of the years.

The amount of evaporation during the warmer half-year (April to September, inclusive) is indicated roughly by Map 6, an original map based on scattered records assembled by the U. S. Weather Bureau.[4] It shows that where water is available, as in the evaporation pans used to get these records, about twice as many inches of water evaporate in much of the Southwest as in the Northeast. In about half of the country, however, the water loss during this half-year is 30 to 40 inches. Thus, there is less regional contrast than might be expected. This is because most of the country differs only moderately in temperature in summer, and temperature profoundly affects evaporation. The northwestward extension of the zone of loss of 30 to 35 inches is associated with the relatively higher summer temperatures in the northern interior than in the cloudier East.

During the average frost-free season, which means a season of varying length in different parts of the country, the ratio of precipitation to evaporation (Map 7) is more than unity* only near the Atlantic and eastern Gulf coast, in the northern Great Lakes region, and in western Washington. For about half of the country, evaporation from suitably exposed evaporation cups is more than twice as great as the precipitation. In most of the West it is more than five times as great. This map is a shaded copy of one by Livingston and Shreve, botanists.[5]

Map 7 also shows that the chief deciduous forest region has a ratio of 70 to 100 between precipitation and evaporation during the frost-free season. The regions where the ratio is more than 100 are characterized by coniferous forests, or at least have many conifers mixed with deciduous trees.

The seasonal variations in evaporation from lakes and reservoirs is large wherever the annual temperature range is wide. For example, Maps 8 and 9 (after Meyer) show that in North Dakota about 15 times as much evaporation occurs in July (Map 9) as in January (Map 8), although July is one of the rainiest of the year and January has least precipitation. In Indiana the range between January and July is about eightfold, but in Florida it averages only about twofold. An interesting detail presented by these two maps is that there is much more evaporation from the Gulf Stream in January than in July because its water is warmer than the air in winter and cooler in summer.

Comparison of Maps 8 and 9 shows that most of the West loses less than an inch of water from a reservoir in January but loses from 8 to 12 inches in July. The large water loss in central Texas in July and the relatively heavy loss in January is an interesting indication of the aridity of that area, which resembles arid west-

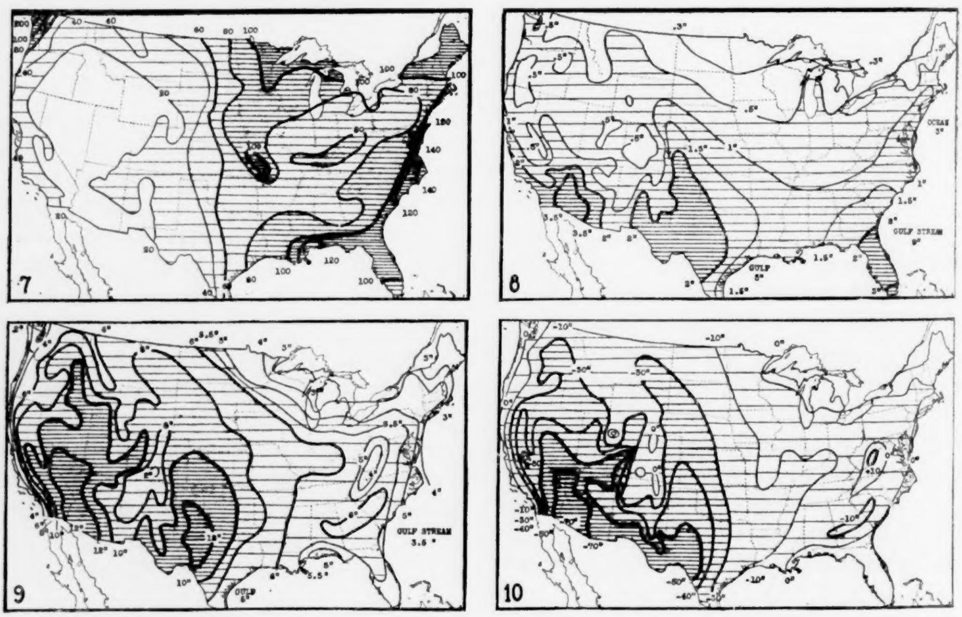
* The ratios are multiplied by 100 on Map 7; equality of precipitation and evaporation is therefore represented by 100.

ern Arizona more than it does most of New Mexico, for example.

The conspicuous southward increase in evaporation from reservoirs and shallow lakes in January (Map 8) reflects the sharp latitudinal difference in average temperatures and is associated with regional contrasts in biologic activity. In July the north–south contrast is much less, except near the Great Lakes (Map 9). This is a result of greater temperature uniformity in most of the country, due in part to the fact that the days are enough longer in the North in July almost to offset the effects of the lower noon height of the sun. The cooling influence in hot weather of the Great Lakes is reflected in Map 9.

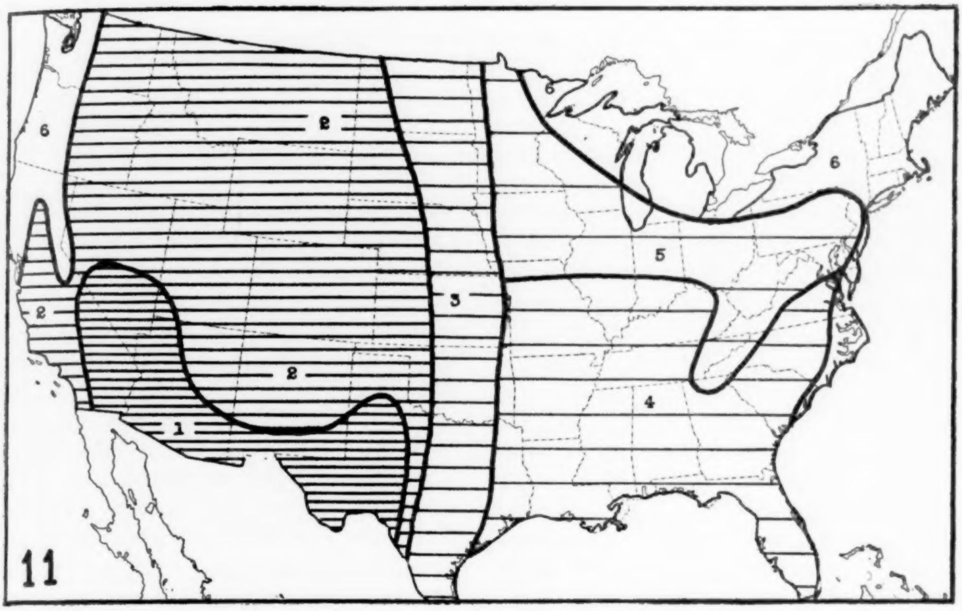
Map 10, also based on one by Adolph Meyer, shows the average differences in the totals of evaporation and precipitation during April to October. Only near the country's borders (northeastern, eastern, southeastern, and northwestern) does precipitation normally exceed evaporation from reservoirs in this period. The excess of evaporation over precipitation is, however, less than 10 inches in most of the eastern half of the country and in a Pacific belt. In the Great Plains region and in much of the West, it exceeds 30 inches; in the most arid section it exceeds 70 inches. The zero line near the east coast is situated approximately where the 100 ratio line is on Map 7 (for the average frost-free season). The zero line near the Pacific coast is, however, quite differently situated than the 100 line on Map 7 and more closely corresponds with the type of vegetation. Wherever there is more precipitation than evaporation during April to October, coniferous or mixed forests prevail.

The final map (11) is an attempted regionalization on the basis of evapora-



MAPS 7–10. SEASONAL EVAPORATION AND PRECIPITATION

7: PRECIPITATION-EVAPORATION RATIOS (×100) DURING THE FROST-FREE SEASON. 8: MEAN EVAPORATION FROM LAKES IN JANUARY (INCHES). 9: MEAN EVAPORATION FROM LAKES IN JULY (INCHES). 10: MEAN APRIL–OCTOBER RAINFALL COMPARED WITH MEAN EVAPORATION (INCHES).



MAP 11. EVAPORATION REGIONS IN THE UNITED STATES

1: EVAPORATION EXCESSIVE THROUGHOUT YEAR. 2: EVAPORATION EXCESSIVE IN WARMER HALF-YEAR. 3: EVAPORATION ONLY MODERATELY GREATER THAN PRECIPITATION. 4: EVAPORATION AND PRECIPITATION BOTH LARGE THROUGHOUT YEAR. 5: EVAPORATION MODERATELY EXCEEDS PRECIPITATION IN WARMER HALF-YEAR. 6: EVAPORATION GENERALLY LESS THAN ANNUAL PRECIPITATION.

tion. The Southwest, region 1, has excessive evaporation throughout the year. In most of the West, region 2, evaporation is excessive only during the warmer half-year. In region 3, evaporation normally is only moderately greater than precipitation. In the Southeast, region 4, both evaporation and precipitation are large throughout the year. In the Northeast and Northwest, region 6, precipitation generally exceeds evaporation except in the warmer weeks of summer. The typical soil type of region 4 is the yellow to red. Region 3 has black chernozem soil, regions 5 and 6 have characteristically gray-brown soils, except in the coolest areas, where podzols occur.

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SUNBURN PROTECTION, NATURAL AND ARTIFICIAL

By ARTHUR C. GIESE and JULIAN M. WELLS*

Experience tells us that accommodation to sunlight is achieved by graded exposure to the actinic rays of the sun. Too rapid and extended exposure results in erythema, or intense reddening of the skin, which may be followed by blistering, desquamation, and tanning. In wide use at the present time are oils, lotions, and ointments which are supposed to prevent sunburn while allowing tanning to occur. Under certain circumstances such results are achieved. It is the purpose here to describe briefly, first, how natural accommodation occurs and, second, how sunburn protection is artificially obtained and how it enables the normal process of accommodation to occur at the same time.

In the popular mind the protection from sunburn is due to tanning, the pigment serving to absorb the actinic rays, and so preventing their penetration through the skin, as was suggested by Finsen (1901). While pigment may protect to some extent, the fact that individuals already tanned may be severely burned by exposure to the sun indicates that this is not the whole story. Furthermore, blonds, without developing pigment, may nonetheless gain some accommodation to the sun's rays. This seeming paradox is clarified by a histological study of the skin, which shows that the pigment resulting from sunburn is largely below that layer of cells mainly affected in sunburn and thus cannot afford much protection to these cells.

A cross section of the human skin is shown diagrammatically in Figure 1. Skin consists of two layers: epidermis and derma, differing in embryonic origin. The epidermis varies in thickness from .07 to .12 mm., except on palms and soles, where it is thickened. It is made up of many layers of cells, cylindrical at the base, dead, flattened, and cornified at the surface, and of intermediate shape between. The cylindrical cells at the very base of the epidermis are active cells, in which mitoses are frequent. They are overlaid by cells with a soft, granular appearance, know as the prickle cells because of their intercellular linkages. Above the prickle cell layer is the granular layer, the cells of which, in the thickened parts of the epidermis, are filled with granules of keratohyalin or eleidin. Above the granular layer are the flattened layer and the scaly layer, the latter at the surface of the skin. In very thick epidermis, as on the palm or sole, a clear layer called the *stratum lucidum* lies between the granular layer and the flattened layer.

The derma, which lies beneath the epidermis, consists of a cushion of connective tissue carrying the blood vessels that supply the derma. It has an average thickness of 1 to 2 mm., except on the palms and soles, where it is thicker. The epidermis has no blood vessels and must receive its supplies by diffusion from the derma. Below the derma is the fibrous connective tissue which binds the skin to the muscles or other structures. In the dark races pigment occurs in the derma as well as in the epidermis, and it is distributed through the latter, making it much more useful as a protection against sunburn than the pigment developed by the white race.

Histological study shows that sunburn

* School of Biological Sciences, Stanford University and College of Pharmacy, University of California, San Francisco.

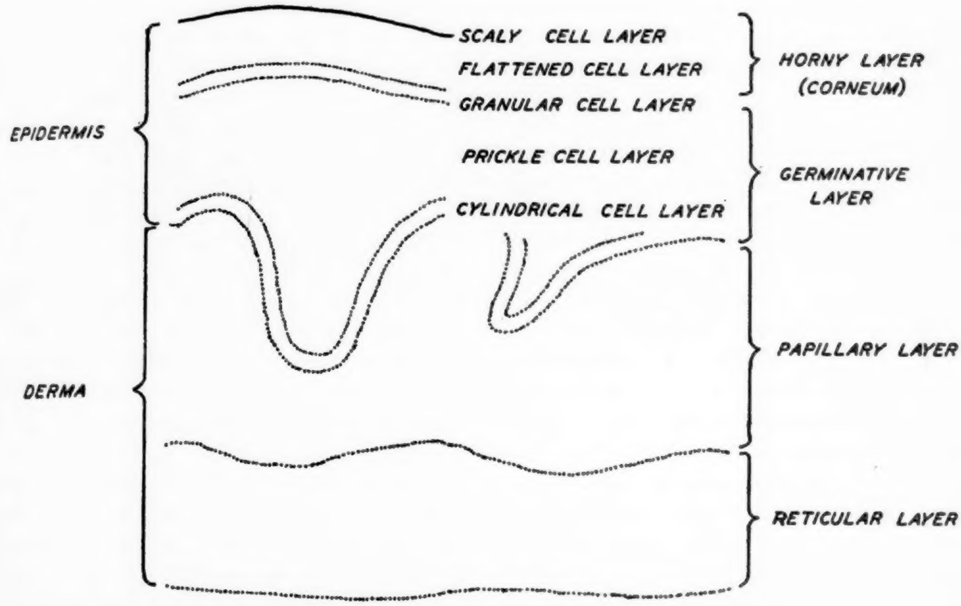


FIG. 1. DIAGRAM OF A SECTION OF HUMAN SKIN

SUNBURN, OR KILLING OF CELLS, OCCURS IN THE PRICKLE CELL LAYER; ERYTHEMA OCCURS IN THE DERMA, ESPECIALLY THE PAPILLARY LAYER, AS A RESULT OF THE DILATATION OF THE BLOOD VESSELS. PIGMENT DEVELOPS CHIEFLY IN THE CYLINDRICAL CELL LAYER (SEE MAXIMOW AND BLOOM, 1942).

injury is largely localized in the prickle cell layer. These cells, in absorbing the light and becoming injured, protect the active, or germinative, cylindrical cell layer below. The production of breakdown products on injury and death of some of the prickle cells is thought to result in the diffusion of chemicals, causing relaxation of the blood vessels of the derma and leading to erythema after a latent period. Considerable injury to the prickle cells is followed by infiltration with lymph, leading to blister formation. Recovery is brought about by the proliferation of a new cover of cells from the germinative epithelium and the shedding of the dead cells (desquamation). Tanning also follows the erythema, but the melanin pigment is laid down by melanoblasts in the basal layer of the epidermis. In this position it cannot protect the prickle cell layer from radiations. Only as the pigment granules later migrate outward in small quantity does the melanin serve to protect the prickle cells.

The thickening of the corneum of the skin subsequent to exposure to sunlight has been shown by Guillaume (1927) and Miescher (1930) to be the main mechanism by which the accommodation to sunlight occurs. While the corneum has little pigment or color, it absorbs strongly in the ultraviolet part of the spectrum. Furthermore, the granular inclusions in the cells, as well as the surfaces of the flattened cells, reflect and scatter the light effectively, preventing it from reaching the sensitive cells below. The greater the thickness of this absorbing and scattering layer of cells, the greater the protection to the prickle cell layer below. The soles of the feet and palms of the hands are not naturally burned, being protected by the thick layer of cornified epidermis; yet by excessive experimental dosages they could be burned.

Since erythema and tanning and thickening of the corneum seem to go hand in hand, all occurring consecutively after irradiation with ultraviolet light, how can we explain the apparent anomaly of sunburn in a tanned individual? The problem is not simple. First of all, the action spectrum, i.e., the relative effectiveness of different wave lengths, is not the same for erythema and tanning. These differences are shown in Figure 2. In both cases, it is true, the wave length of maximal efficiency is the same, 2967A (Coblentz and Stair, 1934; Luckiesh and Taylor, 1939). However, short wave lengths which have erythemal effectiveness do not induce much pigmentation, and wave lengths longer than those which cause sunburn may result in pigmentation. Pigment is formed in the basal layer of the epidermis, and the differential action of different wave lengths may be in part due to differential penetration. Therefore, it is possible that tanning might occur without such action of the radiations on the prickle cells as would evoke thickening of the corneum. Certainly this would be true of the "direct or immediate pigmentation" of Henschke (1943). This type of tanning is produced maximally by wave lengths between 3400–3500A and is presumably due to direct oxidation of the precursor of melanin. It is induced only by a dosage several hundred times as large as that at 2967A (Luckiesh and Taylor, 1939). It can be produced in dead skin; therefore it appears to be a photochemical change. It appears immediately after exposure, as shown in Figure 3, whereas the pigmentation following irradiation with shorter wave lengths appears only after the erythema begins to subside. Furthermore, exposure with large dosages at still longer wave lengths (3600–4800A) may produce erythema and tanning, but this erythema involves a

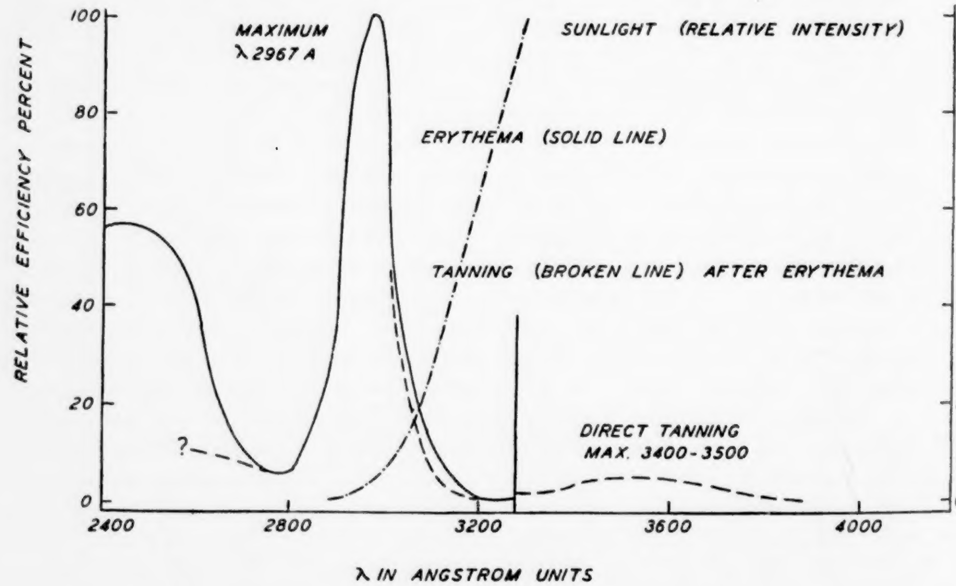
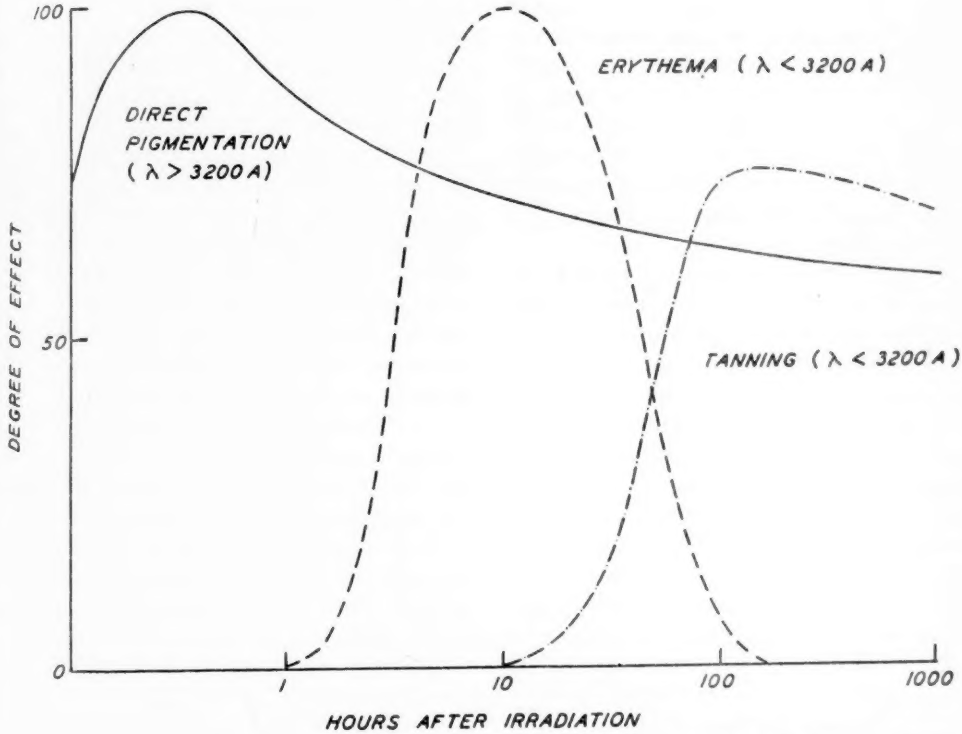


FIG. 2. ERYTHEMA AND TANNING CURVES

ERYTHEMA AFTER COBLENTZ AND STAIR (1934), TANNING AFTER LUCKIESH AND TAYLOR (1939) AND HENSCHKE (1940). THE QUESTION MARK ON THE TANNING CURVE AT SHORT WAVE LENGTHS INDICATES LACK OF ACCURATE INFORMATION. THE VERTICAL LINE INDICATES A CHANGE IN ORDINATE TO THE PERCENT SCALE ON THE RIGHT. FOR LONG WAVE LENGTH ERYTHEMA SEE HAUSSER (1938).



After Hamperl, Henschke, and Schulze (1939)

FIG. 3. TIME OF APPEARANCE OF ERYTHEMA AND PIGMENTATION

mechanism other than the destruction of the prickle cells. The wave length maxima at 3600, 3850, and 4080A—3850 the strongest—suggest hemin absorption. No increase in thickness of the corneum following action of long ultraviolet wave lengths appears to have been demonstrated (Hausser, 1938; Hamperl, Henschke, and Schulze, 1939).

The picture is further complicated by the fact that sex hormones are involved in tanning (Hamilton and Hubert, 1938). After castration only a pasty coloring develops on exposure to the sun. However, injection of testosterone in both sexes is followed by a healthy tanning of previously exposed skin. Estrone also seems to be involved in tanning of women (Hamilton, 1939).

Even if both tanning and increase in thickness of the corneum had occurred simultaneously, a more rapid loss of the corneal thickening than of the pigment might also result in a pigmented individual who did not have much resistance to ultraviolet light. In some individuals tested in our laboratory, pigment once formed tends to remain for years; in others it may disappear in a few weeks. The thickened epidermis subsequent to a single effective exposure lasts at best for about a month (Ellinger, 1941). As previously pointed out, pigment granules are formed extracellularly in the basal layer of the epidermis and are found to migrate into the outer layers of the corneum, from the surface of which they are ultimately shed. The amount of the pigment formed and the rate of shedding varies from individual to individual. Some regions of the body, such as the arms, lose their pigment much more rapidly than do other regions, such as the abdomen, of the

same individual. Apparently, even when no pigment can be detected, the change in the nature of the skin produced by ultraviolet radiations may be revealed by observing the skin under ultraviolet light of long wave lengths, in which the normal skin fluoresces more than the affected skin (Luckiesh and Taylor, 1939).

If prolonged exposure to sunlight or other ultraviolet sources is unavoidable, how can the skin be protected from injury? We can imitate nature by covering the epidermis with something that will both scatter and absorb the active rays of the sun, thus reducing the intensity of the rays reaching the skin to a level that can be tolerated. Materials must be chosen that will absorb or scatter the radiations of sunlight causing erythema and sunburn. These radiations are present in sunlight only to a limited extent—under the most optimal conditions for sunburn only 0.2 percent of the total radiation is erythemic. The relative efficiency of different wave lengths of the ultraviolet in producing erythema is shown in Figure 2 (Coblentz and Stair, 1934). From this graph it is evident that wave lengths not present in sunlight are also effective in producing erythema. The limits of the sunburn radiations in sunlight are also shown.

An ointment or lotion made to protect from sunburn usually contains a compound that scatters light effectively and one that absorbs the sunburn radiations, the latter usually being spoken of as a screen. Talc, kaolin, zinc oxide, chalk, magnesium oxide, and titanium dioxide have been used as light-scattering agents, but titanium dioxide is perhaps most suitable and has been widely employed. The screen is difficult to choose because of the many desirable properties it must possess and the large number of compounds that have been suggested but not yet fully tested. The screen should absorb the erythema-producing radiations very strongly, but it must be nonirritating to the skin. It must not be photolabile, i.e., readily destroyed by the absorption of sunburn ultraviolet, in order that it may remain potent for some time. It must be nontoxic, even if used repeatedly for long periods of time, and it must not be decomposed on the surface of the skin. A very large number of compounds absorb in the region of the erythemic radiations. Quite a few have probably been tried, but unfortunately data on most commercial ointments are not available; and in the case of foreign patented preparations, the formulae of the ointments, as well as the nature of the screens, are not disclosed.

A detailed list of chemical screens that have been tried or suggested would be out of place here, therefore only the main families of compounds need be mentioned as examples of the types of chemicals used: p-amino benzoates, anthranilates (o-amino benzoates), salicylates (o-hydroxybenzoates), cinnamates, pyrones (e.g., esculin), benzimidazoles, carbazoles, naphthol sulphonates, and quinine disulphate. Most of the compounds used are aromatic compounds, and the benzene rings and double bonds usually present are the chromophores which absorb the erythema-producing rays of sunlight. A fairly detailed list of compounds appears in deNavarre's book (1941), and others are to be found in *Chemical Abstracts* from about 1930 to the present, the greatest number appearing just before the war. The relation of the molecular configuration to absorption of ultraviolet is discussed in such books as Brode's *Chemical Spectroscopy*.

The scattering agent and the screen must be put into some vehicle—either an oil, an ointment, or a lotion. Oils generally contain a screen, or absorbing compound. Lotions and ointments generally have both scattering and absorb-

ing agents. The lotion is generally hydroalcoholic and dries rapidly, leaving a thin film of active material on the skin, bound in some film-forming compound such as ethyl cellulose. The ointments are either oil in water emulsions (vanishing creams) or fatty or greasy bases, usually anhydrous in nature. Generally lotions and ointment are made to be relatively easily washed off with soap and water (deNavarre, 1941, gives formulae of bases or vehicles). Pigments are usually added to match skin color, and preservatives to prevent the ointment from decomposing.

Ointments have been used in the armed forces whenever excessive exposure to sunlight has been encountered. Exposure to sunlight on life rafts is particularly severe, but it is also a problem in the desert and in the tropics. Ointments for different regions must have different properties. In general the ointments and lotions for use in the armed forces must have greater resistance against abrasion and sweating than those desired for civilian use.

No ointment, lotion, or oil protects the skin completely—it merely acts as a screen to reduce the intensity of the sun's ultraviolet. The effectiveness of the ointment may be tested in the following manner: The skin is covered with a thin, flexible lead plate containing perforations about .5 inch in diameter. Successive circles are exposed in a graded series to determine the minimal erythemal dosage (hereafter referred to as M.E.D.), or the dosage which causes a just perceptible reddening of the skin. It is important to use skin not previously exposed or skin evenly exposed. Once the M.E.D. has been determined, measured areas of the skin are coated with a known weight of the substance to be tested in order that the comparison may be made in a standard manner. The coated areas are then treated with a graded series of exposures to determine the increase in time of exposure required for a M.E.D. through the ointment or lotion. As a source of radiations a carbon arc or a quartz mercury arc with an appropriate filter such as corex D, to match the quality of sunlight, may be used. If possible, the same intensity should be employed in successive runs. If feasible, final tests should be made with sunlight, since even with a filter the artificial sources are quite different from sunlight.

Calculations show that even under the most extreme conditions no more than 20 M.E.D. units of erythemic radiations fall on a person on a given day (Blum, 1943a). Therefore, to confer complete protection under such extreme conditions, the ointment or lotion should reduce the intensity of the light to about one-twentieth. Some ointments will achieve such protection, but the ones we tried did so only in layers thicker than are practical. However, the exposure is usually likely to be less than 20 M.E.D. Ointments which in thin layers afford a protection of about 10 M.E.D., i.e., requiring an exposure of ten times the M.E.D. before an erythema appears, are available.

Under most conditions considerably less than this protection is required. However, commercial ointments and lotions ought to be graded as to their protective value, and the ingredients used ought to be listed. A convenient method of grading would be the ratio of the M.E.D. values with and without ointment. Ointments made with different bases, or vehicles, differ in their resistance to sweating, rubbing, and washing. Under given field conditions some ointments are rendered useless in a short time and must be reapplied. It is likely that an ointment which is satisfactory for exposure in the snow will not be satisfactory for the beach, the desert, or the mountains in the summer. No ointment should protect so completely

as to prevent some erythemic response after long exposure, since only with exposure is natural adaptation acquired.

Ointments and lotions are made to absorb the potent sunburn-producing radiations and to transmit the direct tanning radiations, since tanning is believed by the public to be not only aesthetically desirable but healthful. The absorbing screen is therefore carefully selected. Scattering agents with selective action over a narrow span of the spectrum are not available.

Sunburn can be a source of suffering, and almost every person seems to require personal initiation to it before he learns to avoid overexposure. Furthermore, continued exposure to sunlight or ultraviolet light from artificial sources may result in malignant tumors (Findlay, 1928). When continued and excessive exposure to intense sunlight is anticipated the individual should protect himself to avoid sunburn. When exposure is gradual and progressive the skin builds up its own protection, mainly in the corneum, or outer horny layer, which becomes thicker.

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SCIENCE ON THE MARCH

AN OLD CHEMICAL COMPOUND REVEALED AS AN EXCEEDINGLY POTENT INSECTICIDE

WHEN Michael Faraday in 1825 treated benzene with chlorine and produced a compound with the comparatively simple chemical formula $C_6H_6Cl_6$, he did not anticipate that in 1946, more than a century later, this material would prove to be the most powerful insecticide known.

Currently referred to as "benzene hexachloride," but more accurately as 1,2,3,4,5,6-hexachlorocyclohexane, this compound is several times more toxic to most insects than the widely publicized DDT, which so effectively served to save thousands of human lives during the recent World War. As in the case of DDT, many years elapsed between the original compounding in chemical laboratories and the discovery of the amazing insecticidal potency of $C_6H_6Cl_6$.

Owing to the exigencies of war and the widespread successful use of DDT in clearing large areas—even entire islands—of disease-bearing pests, that chemical was given well-deserved publicity. The many reports emanating from battle areas too frequently referred to DDT as the "miracle insecticide," and the impression became general that this excellent insecticide is a perfect control for all types of insect pests under all conditions. There are, however, no such insecticides known to trained, experienced entomologists at the present time and scarcely a remote possibility of their future development. Insects are too variable in type, life history, feeding habits, and susceptibility to chemicals for the entomologist to hope for one uniform control measure for the thousands of destructive and dangerous pests.

In comparison with the long chain chemical formulas of pyrethrins I and II, which have been effectively used throughout the world as insecticides, $C_6H_6Cl_6$ is simple indeed. However, this apparently simple formula is complicated from the use standpoint by the existence of at least four recognized "isomers," indicated as *alpha, beta, gamma,* and *delta.* Strangely, the *gamma* isomer, which usually comprises only 10 to 12 percent of the total bulk, carries practically all the potency as an insecticide and, with the *delta,* is reported to make up approximately 25 percent of the total product, the remaining 75 percent being composed of *alpha* and *beta* and residues with little insecticidal value.

Fortunately, the *gamma* and *delta* isomers are soluble in varying percentages in more than 40 recognized chemical solvents, thus affording a ready means of segregating the portion having insecticidal value. This *gamma* isomer will be used extensively in aerosols, general flysprays, and in those operations requiring a purer product than the crude material, which has a peculiar musty, though not disagreeable, odor. The crude product, which is rather inexpensive considering its high insecticidal value, can be used in combination with various dust diluents such as clays, talc, etc., for applications to many field crops.

Preliminary tests of these dusts on cotton indicate great efficiency against cotton boll weevil, cotton flea hopper, sucking bugs, aphis, and thrips. Acting as a contact, stomach, and fumigant insecticide, $C_6H_6Cl_6$ appears in some phases of insect pest control to combine many of the values of arsenicals, nicotine, and rotenone and the several fumigants now in use.

English scientists report that only one part of *gamma* isomer to 1,000,000 parts of grain killed 100 percent of the common grain weevils (*Calendra*) under controlled fumigation conditions. And re-

cent tests in the United States indicate similar fumigation results on the same species of weevils in grain from the use of one part of the crude (containing approximately 10 percent *gamma*) in 100,000 parts of grain.

In the control of mosquitoes and flies under varied field conditions as well as in human habitations, the *gamma* isomer has shown amazing toxicity, with a killing power 8 or 9 times that of DDT and about 18 times that of pyrethrins. In field tests, including some in Western Africa and Ceylon, one-half pound per acre of the crude material in the form of dust produced 100 percent kill of mosquito larvae in 24 hours—an indication of the usefulness of benzene hexachloride in controlling these disease-bearing pests over large areas with applications made from airplanes. When incorporated in grasshopper baits the crude chemical indicates a toxicity approximately 10 times as great as sodium arsenite, according to reports from European authorities.

Benzene hexachloride apparently does not have the long residual effect in controlling houseflies and mosquitoes that is characteristic of DDT. The more rapid evaporation of benzene hexachloride is advantageous in that it will permit its general use in the spraying of fruit and vegetable crops without the danger of residues remaining which, in the case of certain insecticides, must be removed in order to meet Federal and State marketing and food regulations.

Many questions regarding the proper utilization of this new insecticide in many phases of crop pest control remain to be investigated; results of the rather scattering preliminary tests have made this entire problem most intriguing to economic entomologists. Several years will be required before fairly complete information regarding its possibilities in pest control will be available because of the various climatic and seasonal conditions under which our crop pests thrive and develop. Temperature and moisture often strongly influence the development of pests and the value of control methods. Many experiments are being planned by Federal and State entomologists for the approaching growing season to test the efficiency of the insecticide in various parts of the country.

The excellent and informative lecture by R. E. Slade, published and illustrated in *Chemistry and Industry,* October 13, 1945, should be carefully studied by everyone who proposes to carry on studies and experimental work with this promising insecticide. The article is replete with useful information on the chemical and physical properties of the compound. Reported results of early tests on a fairly wide range of injurious insects point to a broad field of usefulness in the control of insect pests of agricultural and horticultural products, domestic animals, and mankind.

Several brief reports by investigators in America have appeared in recent months, all confirming the exceptional insecticidal values of this long-neglected simple chemical compound. Entomologists everywhere sincerely hope that the public will make use of benzene hexachloride according to the recommendations of trained Federal and State entomologists.

J. G. Sanders
Commercial Solvents Corporation
New York

MILITARY GEOLOGY

World War II was an all-inclusive war. It made use of global terrain and most of the natural and manufactured resources of the entire world. Tides of battle were often influenced or altered by the nature of soils, waters, forests, and mineral resources. Beach and terrain configuration and composition obviously were of fundamental importance. It would require a long narrative to re-

count properly the value and use of these groups of natural resources, not only in the theaters of combat but also in the far-flung supporting hinterlands. Those accounts cannot be given here.

The conflict just ended was, as never before, a war of applied geology and of the use of mineral resources. One may not glean that impression from the recitals of invasions and of violent contests in the air, on land and sea, and under the sea, for those fundamentals were only a part of the primary background. However, the vital role of certain mineral resources—for example, coal, iron, and petroleum—in winning the war for the Allies and losing it for the Axis is rather generally known to scientists and to thoughtful laymen.

The accomplishments of "military geology," in close and constantly accelerated application to countless war problems involving world-wide terrain, beaches, soils, rock supplies, water resources, and mineral commodities, are largely contained in technical maps and reports prepared for governmental agencies and the armed forces. Much of the assembling and interpretation into military terms of terrain and other geologic intelligence for direct military use, at both strategic and tactical levels, was done by a highly organized special group set up for that precise purpose. That group was the Military Geology Unit of the U. S. Geological Survey.

In addition, scores of geologists and engineers with the necessary geologic training were literally scouring the earth for new supplies of critically needed raw mineral resources demanded by the multitude of industries charged with the duty of supplying the unprecedented, stupendous, and incredibly varied sinews of war to the armed services at home and around the world. They were using their special skills to ferret out and put into production the mineral deposits from Alaska to Argentina and from Australia to Africa. Many of those "treasure hunts" are thrilling tales aside from their contributions to the winning of the war. It would be difficult to overstate their value, for this was a global war based on an endless supply of many kinds of mineral resources.

In a more special sense, military geology dealt directly with the compilation of technical geologic data and their interpretation to officers of the Army, Navy, and Marine Corps. It must be borne in mind that few of the men charged with the grave responsibility of over-all and detailed planning had a working technical knowledge of geology. But they understood maps and charts of all kinds. Obviously, then, geologic information could be most useful if placed on maps which showed quickly, comprehensively, and as accurately as both data and time permitted, those field facts of military importance. Army GHQ came to depend upon these maps in planning campaigns and invasions. Field commanders found them indispensable in the execution of tactical maneuvers. In some instances, a large folio of maps was prepared and on its way within twenty-four hours after an urgent request had been received from a theater of operations.

The conventional topographic map in four colors showing all of the surface features of an area is most useful in war as well as in peace. But it is far more useful when supplemented by the geologic data to which the topography is intimately related. The character and structure of the "hard" rocks and the nature of the soils derived from them were of crucial importance in many places. The potential amount and character of surface and underground water supplies could be forecast, in the main, prior to an invasion; well sites could be selected so that combat troops would not lack an ample supply of water; large installations with the water requirements

of cities could be planned. The sites of airfields, a *sine qua non* of World War II, and the sources of stone for their construction could be selected well in advance by the application of geologic knowledge. Even the suitability of the terrain and the soils for the digging of foxholes could be predicted. The location of observation posts, of the most favorable routes for the movements of troops, and of protected advance lines could often be indicated. Disasters on invasion beaches were often minimized or prevented by the foreknowledge of surface features and materials that must have resulted from the working of geologic processes on the rocks in those areas. Striking examples were last-minute changes in the carefully prepared plans for the invasion of certain Pacific islands and the construction of airfields on them, as soon as terrain intelligence became available.

All these valuable data, and many more, were supplied by an extremely busy group of about 100 military geologists in secret quarters in Washington. Their efforts were constantly supplemented by the work of overseas teams assigned to field duty with combat units and by other geologists who were members of the armed forces and who were assigned to several specialized service units. Geologic work on the ground in the combat areas was particularly necessary where data pertaining to those areas were not available in advance of operations. Still other geologists throughout the nation and around the world were getting other essential information.

Maps depicting terrain intelligence were constantly needed. They included maps showing topography in perspective; terrain appreciation, that is, the appraisal of terrain features that affected the movement of ground forces; trafficability of areas; prospective airfield sites; water supplies; sources of construction materials; and all other geologic data of use to military forces.

How could this be done, even with unlimited time at the disposal of research geologists? And how, especially, could some herculean task be accomplished for all practical military purposes within the space of one day or, at most, several days? In ten days the Military Geology Unit prepared their maps for the invasion of Sicily! It could be done effectively because in most countries outside of the United States geologic maps of much of the country had been prepared in the normal course of peacetime surveying of the soils, mineral deposits, and other natural resources upon which national economy depends. As a rule, copies of those maps were available in libraries in this country. They were supplemented by many maps made by American and British geologists and engineers and by photographs taken by them, as well as by aerial photographs taken on the spot. In the words of a report summarizing this work:

> All of this underscores the main lesson of the war: that in preparing for the future—be it war or peace—American geologists can accomplish nothing more important than to complete areal mapping of geology and soils throughout our own country and in some places abroad.

Yet, the United States is only about 7 percent mapped!

ARTHUR BEVAN
VIRGINIA GEOLOGICAL SURVEY

BOOK REVIEWS

BIOLOGICAL FIELD STATIONS

Biological Field Stations of the World. Homer A. Jack. Chronica Botanica, Vol. 9, No. 1. 73 pp. $2.50. The Chronica Botanica Company, Waltham, Mass.; G. E. Stechert & Co., New York. 1945.

This paper is a very welcome addition to the literature on an important aspect of education and research. Field stations seem destined to expand greatly as the application of scientific methods is extended to the biological and ecological resources of the world and as their utilization comes under intelligent supervision. The impulse given to science and its application by the war is unprecedented and should be utilized to make needed improvements. Such an advance will be in direct proportion as textbook teaching and urban laboratory methods are balanced with field studies of biology and ecology. Decentralization will facilitate this. There has been much lip service paid to the direct study of living nature, and much less actual practice. This is because it is more difficult to make the field studies on account of the inadequate facilities available for other kinds of study. Administrative reorganization is needed before changes can be made. We may look upon field stations as a social invention devised to assist teaching and research, which in general can be done better by an institution than by the isolated individual. Stability, continuity of policy, and coordination are the advantages of such an organization.

It would be a mistake to consider these biological field stations merely as specialized or technical institutions, and overlook the fundamental fact that their direct and objective method should be extended over much, if not most, of the educational system, from the bottom to the top. Nurseries, camps, and summer schools are needed at the elementary level, and corresponding camps, schools, field stations, excursions, and travel are likewise required at the intermediate and all higher levels, before these methods can be integrated and absorbed into the whole educational system. The natural history sciences and agriculture have done a great deal of the pioneering in this field, and others should now study their methods and apply them to other fields, particularly to the social sciences. The words of John Dewey on this general subject cannot be repeated too often:

> One of the only two articles that remain in my creed of life is that the future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind. . . . The other "article" is faith in democracy as a social mode of life.

About half of this paper on field stations is devoted to a discussion of the broad general aspects of the subject, including such phases as their purposes, history, administration, equipment, facilities, instruction, and research plans. This appears to be the most comprehensive discussion of their functions that has been produced. Every phase of their work is discussed briefly, including condensed references to the literature (so condensed, however, as to make them difficult to use in a private library).

This discussion deserves careful study, particularly by those educators who are seeking to improve present educational conditions. It is just these persons and those who have huge funds to make educational studies and surveys who need to give serious attention to the broader implications and applications. I have yet to see the first of such studies that has given any adequate recognition to this whole field and its bearing on educational methods in general. This without question is a critical period for making these new evaluations.

Every former student of Dr. C. O. Whitman will welcome the recognition of the role he has played in grasping and expressing the fundamental functions of these field stations and the conditions most favorable for their success. In 1902 (*Biol. Bull.*, **3**, p. 214) Whitman said:

> The biological laboratories of today in design, equipment, and staff, are almost exclusively limited to the study of *dead* material. Living organisms may find a place in small aquaria or vivaria, but they are reserved as a rule, not for study, but for fresh supplies of dead material. . . . These fundamental problems require, therefore, to be taken to the field, the pond, the sea, the island, where the forms selected for study can be kept under natural conditions, and where the work can be continued from year to year without interruption.

Later on he adds (p. 216):

> The functions of a biological farm are not summed up in experimentation. That old and true method of natural history—*observation*—must ever have a large share in the study of living things. Observation, experiment, and reflection are three in one. Together they are omnipotent; disjointed they become impotent fetishes. Biology of today, as we are beginning to realize, has not too much laboratory, but too little of living nature.

No one has better expressed these relations than Dr. W. K. Brooks, who said:

> To study life we must consider three things:
> *first,* the orderly sequence of external nature;
> *second,* the living organism and the changes which take place in it, and
> *third,* that continuous adjustment between the two sets of phenomena which constitutes life.

These statements were made before the active expansion of modern ecology with its insight in biological problems.

The remaining half of the paper is devoted to the 1939–1940 status (qualified by war conditions) of these stations, including a condensed descriptive directory of the field stations or laboratories arranged alphabetically in 59 political units, beginning with Alaska and ending with Yugoslavia. When available, a brief sketch is given of each station, and reference is made to official and other publications. The author has visited 79 of these in 18 countries out of the total of 271 listed.

The list appears to be reasonably complete, but one notices the absence of Hastings Natural History Reservation in California, the Roosevelt Wild Life Forest Experiment Station, with its 15,000 acres of Huntington Forest in the Adirondacks, the Edmund Niles Huyck Preserve near Albany, N. Y., and the Petuxent Wildlife Research Refuge, conducted by the United States Fish and Wildlife Service (1939) in Maryland.

This study is without question an important and useful contribution. The editor of Chronica Botanica, Dr. Frans Verdoorn, has expressed a willingness to publish a historical account of these stations which merits hearty commendation.

CHARLES C. ADAMS

ALBANY, N. Y.

PRINCIPLES AND PROBLEMS OF PUBLIC MEDICAL CARE

Public Medical Care. Franz Goldmann. 226 pp. $2.75. Columbia University Press. New York. 1945.

PUBLIC medical care has grown to be an immensely important facet of society. Its growth has been largely haphazard and therefore asymmetric. The first and major portion of Dr. Goldmann's book traces the development of public health services and public care of the sick. It presents a broad historical perspective upon which the second part, entitled "Directed Growth," is based. This second part deals with plans for hospitals, clinics, laboratories, and the like, with special emphasis upon centralized administration and some consideration of the economics involved. The book presents the development of public medical care as a social movement. It serves a useful function in presenting some of the deficiencies of existing public medical services, though certain fundamental inadequacies are completely ignored. That

there is need for critical analysis should be obvious. There can be no question but that there is ample room for improvement, but organization alone will not suffice. The book is written from the viewpoint of the social worker primarily concerned with institutions, not from the viewpoint of the physician concerned with individuals. It is notably lacking in appreciation of the truly American tradition of individual initiative. Its basic philosophy will not appeal to scientists.

The concept that medical care is a government function has many strenuous advocates today in addition to Goldmann. They fall chiefly into three groups:

(*1*) Those whose general inadequacy and immaturity (inability to carry responsibility) keeps them in the numerically, and therefore politically, important class of the "have-nots" in an economically competitive society;
(*2*) politicians, both elected and appointed, fostering paternalistic schemes to bolster their political power by offering something for nothing; and
(*3*) idealistic dreamers who escape reality by conjuring up an ideal state in which all responsibility rests upon the government.

The primary premise of these proponents of socialistic medicine is clearly stated in the opening sentence of the *Preface* of Goldmann's book: "Adequate medical care is a fundamental human right." This dogmatic assertion is of very questionable value. Health is a privilege and not a right. As a privilege it inevitably entails responsibility. To evade responsibility it is easy to transpose privilege into right. The primary responsibility for the maintenance of health in an adult must be accepted by that individual, or else all schemes for medical care will fail. No amount of medical service can "give" health, unless individual men and women take sensible care of themselves. We have schools for all, or nearly all; but schools cannot assure the development of good sense in all the pupils. Learning requires study; health maintenance also demands individual effort. To deny this is to retard the development of human capacities and encourage dependency.

EDWARD J. STIEGLITZ
WASHINGTON, D. C.

PROLEGOMENA TO AN INQUIRY INTO THE PROBLEMS OF MEDICAL CARE, II*

Government in Public Health. Harry S. Mustard. xx + 219 pp. $1.50. The Commonwealth Fund. New York. 1945.

AWARE of the unsatisfactory situation with reference to the purchase and distribution of medical care, the Council of the New York Academy of Medicine established in the winter of 1942 the Committee on Medicine and the Changing Order. The Committee began its work in February 1943, charged with the following duties:

(*1*) To explore the possibilities and to formulate methods of maintaining and improving standards of quality in medical service, including medical research, medical education, the maintenance of health, both physical and mental, the prevention of disease, and the treatment of disease.
(*2*) To study the means of making available to larger groups of people and to the country as a whole the best-known practice in preventive and curative medicine.
(*3*) To explore the possibilities and to formulate proposals of distributing these services not only to a larger number but also at a lower per capita cost than the present system permits.

The Committee, recognizing the need for objective data, early enlisted the cooperation of a number of experts in the preparation of a series of monographs on the reciprocal effects of medicine and the technological, social, economic, and political changes that have taken place in American life. The Committee believed that such monographs will offer

* Monograph I reviewed in THE SCIENTIFIC MONTHLY, 60: 319–320 (April 1945).

not only a survey of the present situation, but will also indicate its evolution and possible future trends.

In addition to the publication of the monographs, the Committee intends to issue a report presenting any conclusions that might be drawn from its deliberations and studies.

The present monograph by Dr. Mustard is the second of the series to appear. The author set himself the multifaceted task of investigating the genesis, growth, and future of the public health movement in the United States with reference particularly to various political and social forces. The book contains six sections: Certain Preliminary Considerations, Federal Health Services, State Health Departments, Local Health Departments, Activities of Government in a Public Health Program, and a Summary of Trends and a Consideration of Certain Needs. For supporting evidence there is included a set of well-chosen and informative tables showing, among other things, the total and per capita annual expenditures for health activities by state and territory, according to various important categories. Two historical documents are carried by an Appendix.

The first section is devoted to groundwork material with emphasis on the biological and social factors in health and disease, the character of public health problems, factors that express the seriousness of a public health program, aesthetics and public health, relationships between official and voluntary health agencies, professions that participate in public health work, education for public health work, and government in its relation to public health work.

The longest section, Federal Health Services, refers to "unwise separations" and "unnecessary overlapping of functions" at the Federal level and gives a political history of the various agencies participating in health activities. Activity interrelationships are pointed out. The material is well documented; the reader interested in the political aspects of the Federal health movement will find the references sufficiently complete to guide him in further study.

In the section on the state health department the author indicates that the situation with reference to the state level is to some extent static when contrasted with the Federal level where "great forces are stirring," and from which "new pressures and resources may come." The greatest public health power, according to Mustard, resides in the state health department.

In the analysis of the development of the state health department, attention is drawn to two significant facts. First, in the establishment of the Constitution, the states did not cede to the Federal Government the responsibility and authority for the preservation of health within their borders; and, second, local action, so far as public health measures are concerned, preceded state-wide programs. State-wide action appears to have been precipitated in most instances by the recognition of an epidemic.

Attention is directed to the health work in the state carried by agencies other than the health department. This work, according to the author, while important, is in many instances on the periphery of the public health program.

In his discussion of expenditures by the state health department, Mustard refers to the matter of Federal grants-in-aid for health purposes. He points out two sociological problems that are involved, the soundness of the general principle of Federal grants, and the effect of such grants upon the appropriating bodies and the state health officers.

In the author's presentation of his material on local health departments, which includes origins of local health services, types of local health organizations, basic activities in local health programs, and costs of local health service,

he reminds the reader that "there are comparatively few local jurisdictions, outside the cities, that can alone support an adequate health program." Reference is also made to the author's conviction that if the belief is regarded as "old-fashioned" that people and local government ought to pay a part, at least, of the costs of benefits received, "then there could be no objection to direct rendition of all local health service by the state provided that (a) it is adequate in amount and (b) it is a part of a continuing, coordinated, balanced, and effective program."

In the section devoted to activities of government in a public health program reference is made to vital statistics, sanitation, acute communicable diseases, tuberculosis, venereal diseases, laboratory services, nutrition, hygiene of maternity and young childhood, school hygiene, industrial hygiene, health education, public health nursing, dental problems, mental hygiene, cancer, and heart disease.

The last section of fifteen pages presenting "A Summary of Trends and a Consideration of Certain Needs" is of especial interest. Among the trends referred to are two which are considered by the author to be particularly strong, the trend toward a more powerful Federal Government and the trend toward a more socialistic Federal Government. The paramount need, according to Mustard, is an adequate health service for citizens of every community.

The known deterrents to the establishment of a plan for the providing of adequate local health service are listed. In the opinion of the author these difficulties, while real, may be overcome. There are three requisites involved:

(*1*) The granting to a state of Federal subsidies for health work only if that state submits an over-all plan which will insure effective local health service in each of its local jurisdictions;

(*2*) mandatory state legislation requiring each unit of local government to participate financially in providing its citizens with an effective local health service; and

(*3*) state legislation, when indicated, that would require combined administration of the public health activities of local units of government so that service might be performed on an economical basis and with reasonable completeness.

Dr. Mustard has performed a difficult task extraordinarily well. As scientifically as it is possible in an inquiry of this kind he points out the good and the bad and makes practical suggestions for future developments based on his findings and his wealth of experience.

The book is adequately indexed. The typography and binding are uniform with the first monograph of the series.

This timely, well-documented, interestingly written, and thought-provoking book is recommended to public health workers, legislators, and all others interested not only in the specific problem of the provision of adequate health services to the citizens of this country, but also in the genesis, growth, and future of the public health movement in the United States.

W. M. Gafafer

Washington, D. C.

INSECTS AND THEIR FOOD

Insect Dietary. Charles T. Brues. 466 pp. $6.00. Harvard University Press. Cambridge. 1946.

The diversity of insects is so great that only an experienced entomologist of vast erudition and literary talent could succeed in writing a readable account of insects in relation to their food. Professor C. T. Brues has accomplished this feat at the culmination of his distinguished career in entomology. Primarily a naturalist, he is noted for his broad interest in insects. Whereas most entomologists nowadays are specialists, some even devoting years to the study of the control of a single species, Professor Brues has roamed over the whole field.

Taxonomy, morphology, phylogeny, physiology, pathology, paleontology, and the biology of insects in the field have engaged his attention. He has refused, however, to become involved in the chemical control of insects and is not regarded as an economic entomologist. Furthermore, he has not tried to become a modern experimentalist, using the new techniques and equipment of statistics, physics, and chemistry. The reader of *Insect Dietary* will find that Professor Brues is a natural philosopher—a man who has gathered innumerable facts about insects and has fitted them together to give them meaning.

Insect Dietary can be read with interest by anyone who has studied general entomology, but it will be particularly useful to graduate students of entomology, both for its stimulation to research and for its facts and interpretations, which may be called for in a general examination. And in spite of the multitude of facts contained in it, the reading of it will not be tiresome because Professor Brues writes smoothly and often interpolates quizzical comments on the human scene. For example:

> A complete survey of the materials which furnish food for insects would involve a compilation of stupendous proportions, . . . suited only for a Federal Aid or Economy Program.
>
> This competition [between plants and insects] is really a swinging or fluctuating relationship which developed over the course of countless years, long before our ancestors conceived the Utopian dream of making the world over purely for human consumption.
>
> [Insects] see best by ultraviolet light and poorly by the longer wave lengths that enable us to appreciate the beauties of a tropical sunset or to halt at a traffic light.

Each of the ten chapters opens with an appropriate quotation, sometimes taken from an ancient tome, and closes with an extensive bibliography. The latter adds up to 193 pages in the whole book. Relatively few references to the bibliography are made in the text, and footnotes are rare; thus readability is enhanced.

The first two chapters set the scene, impressing the reader with the abundance and diversity of insects and the general types of their food habits. Professor Brues recognizes four types: herbivorous, carnivorous (predatory), saprophagous, and parasitic. He adds, "We might make a more elaborate classification of food habits but this would add confusion rather than clarity, for whatever types or definitions we may select, there always remains a residuum of forms which do not fall decisively into any one group."

The next three chapters deal with the vegetarians among insects: the herbivorous forms, the gall insects, and those whose true foods are fungi or microorganisms.

The last five chapters are on the carnivores: predators, external and internal parasites, and on insects as food for man and other organisms.

Insect Dietary is pleasing in appearance as well as in content. It is illustrated with 68 line drawings of insects and their parts. These illustrations, derived from various sources, were redrawn by competent artists to give a desirable uniformity of size and line. The 22 plates are excellent half tones, most of them from photographs taken by Professor Brues. The book ends with separate author and subject indexes.

To C. T. Brues and his wife, to whom he dedicated his book, I say "well done!"

F. L. CAMPBELL

COMMENTS AND CRITICISMS

Pro-Haber

Dr. Haber's "Basic English for Science" in the last SCIENTIFIC MONTHLY is excellent and deserves wide attention. It should be required reading for every writer who has ever been guilty of propagating scientific gobbledegook.

While the use of "person interested in the earth's history" is a bit roundabout as an equivalent for "geologist," I feel that many of the readers of SM will heartily welcome the thesis put forward by Haber.—IRA M. FREEMAN.

Haber, Schmidt, and Johnson

Referring to your statement that you would like to know what we readers think of Dr. Haber's article, I want to say that it is of a very high order, and just the sort of article which I should think SCIENTIFIC MONTHLY readers would enjoy.

Also, the article by Mr. Schmidt is "excellent," and he sets forth what a naturalist *is* more clearly than any other American writer.

You did not ask me what I thought of putting anything by Owen Johnson, B.A., in THE SCIENTIFIC MONTHLY but I am going to volunteer the remark that it is "bad medicine," for SM should not be a receptacle for hack writing.—WILLIAM PROCTER.

Gilding the Lily

THE SCIENTIFIC MONTHLY reached an all-time low when its editor stooped to publish an anonymous and libelous letter purloined from a freshman girl's notebook, even though its contents are approved by the author of the paper on "Basic English for Science." Tom Haber did not take the trouble to verify the alleged quotation from our textbook nor the source of the young lady's statistics. Mr. Haber labors under the impression that students in our classes study books rather than plants and plant processes. If he had examined the textbook he would have discovered that the book was written to supplement what is learned in the classroom. "Nonymous" had no need to suffer mental anguish over the word "primordium" since she had seen primordia and examined their structure before she had any occasion to read the chapter on leaves. Furthermore, where this word is first used it is defined and illustrated. Mr. Haber's general characterization of science teaching and science texts makes one wonder whether his competence as a critic is based on investigation, or on intuition. To exemplify the need for Basic English where could he have found an author that needs "translating" less than Sir Charles Lyell? This is indeed painting the lily!

If this process of denaturing literature is so important why does not your author apply it to the writings of Shakespeare, Milton, or Carlyle which must be read by junior college students?

I am writing this letter to you because it seems to me that if your selected authors lack judgment as to what is fair, honest, and accurate you will have to be held responsible for their statements.—E. N. TRANSEAU.

Conservation of Naturalists

I would like to compliment Karl P. Schmidt on the excellent article "Naturalists for the Foreign Service" in your valued publication THE SCIENTIFIC MONTHLY of March 1946.

I am quite sure that all of the good people who are truly interested in the conservation of the natural beauties and natural resources of various countries, and not those of us that are only interested in the mere exploitation of these places, would and should welcome any means, such as has been suggested by Mr. Schmidt, in the furtherance of that good will, by the aid of our naturalists in their midst.—HENRY B. CHASE, JR.

Scientific Diplomacy

The article "Naturalists for the Foreign Service" by Karl P. Schmidt in your March 1946 issue is a notable one, as it opens the possibility of utilizing an unused source for a foreign service personnel. Those of us who have carried on scientific exploration and field work in the Latin-American countries, as well as in other parts of the world, are keenly alive to the facts pointed out by Mr. Schmidt—that the nationals of other countries react in the most favorable manner to intelligent observers.

Naturalists, as a rule, have the special facility of understanding combined with the spirit of inquiry. It might be difficult to obtain a large number of people who are fitted both to handle foreign service problems and to carry on scientific activities. But there are some and they could do outstanding work.

In addition to following the suggestion of Mr. Schmidt, it would also be very wise for the Division of Cultural Cooperation of the State Department to explore the use of Scientific Attachés of the various Embassies—something for which there is a great need.—W. STEPHEN THOMAS.

THE BROWNSTONE TOWER

Although the view from the Brownstone Tower is extensive, I felt the need of a wider and different view of places and people. Fortunately I was given the opportunity to extend my horizon by flying to and from the meetings in St. Louis.

I shall not attempt here to report on the meetings, for one person can see only a little of so large a gathering, but perhaps I can record some impressions for those who could not go.

As the Boston meetings of 1933 are remembered as the frigid meetings, so the recent St. Louis gathering may be recalled as the shirt-sleeve meetings. Summer was treading on the heels of spring and driving out blossoms, leaves, and perspiration. The symbol of the meetings was the park bench on which I saw a man sleeping as I walked one morning from my hotel to the Auditorium. No doubt the sleeper was not a scientist, but many a scientist who had the fortitude to go to St. Louis without a hotel reservation must have wondered whether he would be forced to sleep on a park bench. So far as I know, everyone who came found a bed or cot under a roof, though the attendance was much larger than expected. Those who had rooms shared them with others, and the Association's Housing Bureau placed many visitors in private homes.

Having solved the housing problem, the visitor was free to sample the innumerable attractions of the meetings. On the first evening the large Opera House in the Kiel Memorial Auditorium was filled for the General Meeting of the Association. Following the adoption of the new constitution of the Association, the spotlight fell on that grand old warrior, A. J. Carlson, as he delivered his presidential address. Reading without glasses, he stood at the rostrum in a sack suit, giving the world a piece of his honest mind. More formally dressed ladies and gentlemen of distinction sat on the stage behind Dr. Carlson. Serving as hosts for the Association, they formed a receiving line at a reception that followed the General Meeting. In the same hall on the next night the biologists staged their annual mob scene. Clogging the entire room, they circulated by a sort of Brownian movement, literally bumping into acquaintances and emitting vast volumes of sound and smoke. After such confusion it was good to retire to the quiet of a hotel room.

I prefer the less frantic and friendlier gathering of specialists at a society banquet with good talk among friends around a table. After the dessert comes a tinkle of glass at the speakers' table and the performance begins. If the toastmaster is brilliant and the principal speaker entertaining so much the better, but regardless of the quality of their wit and wisdom the evening passes pleasantly because they are well-known men whom the audience is glad to see in a place of honor.

It is still better to attend a scientific meeting in one's own specialty, particularly if the meeting is not a dull parade of ten-minute papers but a planned program on subjects of current interest. With good speakers and a keen leader such a meeting creates informal discussion and brings out both the known and the unknown.

But best of all is the thrill of coming upon an old friend in the lobby, to sit down with him in a corner, or, better, to detach him from the crowd altogether and retire to a hotel room for a long, uninterrupted talk.

At the St. Louis meetings I moved among masses, crowds, groups, and individuals. I attended big meetings and little meetings, large dinners and small dinners, Council meetings and informal meetings, but of them all give me an individual meeting—the happy smile and the warm handclasp of an old friend.—F. L. CAMPBELL.